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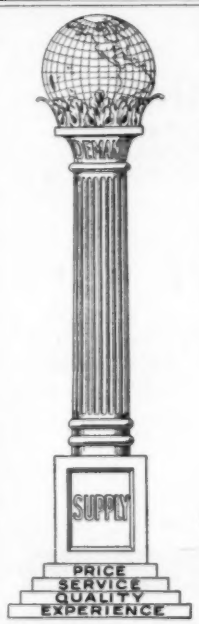

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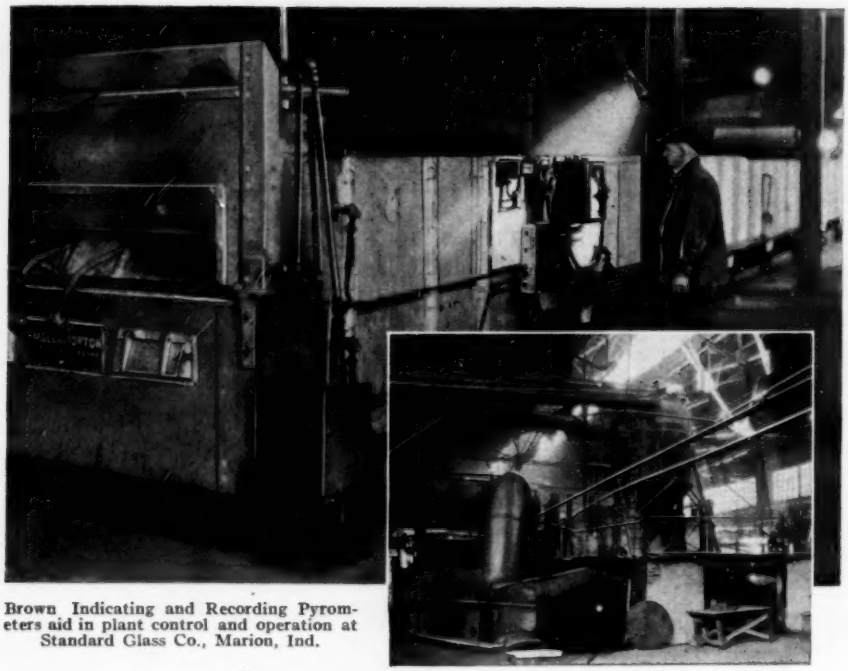

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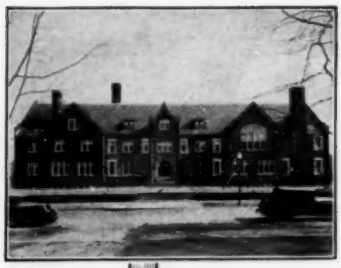

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THE USE OF POLARISCOPES IN THE GLASS INDUSTRY[1]

By F. W. Preston

ABSTRACT

The action of polarized light as a means for detecting strains in glass is interpreted along two distinct lines: one a simple mathematical treatment of the resolution of simple harmonic vibrations, the other by means of physical analogies. The purpose is to give a presentation which can be followed without any mathematical training and at the same time to give a slightly more complex discussion for the more advanced technologist. Various types of polariscopes for detecting and measuring strain are discussed.

Introduction

Of all misleading instruments the polariscope is perhaps the worst, and there is no hope for this state of affairs so far as the polariscope is concerned. The only remedy is a better understanding of it by the user, for with a polariscope, one-tenth of the work is observation and nine-tenths is interpretation.

Polariscopes have frequently been described to the glass industry, but their intelligent use, and the interpretation of their findings, have not. The reason is that the writers themselves rarely understand them.

The polariscope is used at present by glass technologists solely for looking for "strains" in glass, and usually for strains due to defective annealing, though this latter is not the only use that can be made of it.[2] In any case, it is necessary to know something about stresses and strains, and something about optics. The glass technologist to date has usually been more of a chemist than an engineer or physicist. He does not claim to understand the theory of elasticity or the theory of light, but until he understands a few rudiments of both subjects it is difficult for him to use the polariscope with pleasure or discrimination.

---

[1] Some time ago I had occasion to investigate strains in glass. Having made no previous study of the subject, I sought a condensed account, written primarily for the glass technologist rather than for the physicist or petrologist, containing an explanation of polarized light, polariscopes, and particularly interpretations of observations therewith. While treatises related to the general subject in one way or another were available, I was disappointed not to discover in existing literature such an account as I wanted. At this stage I explained my needs to Dr. Preston, who kindly wrote the following paper for my information. When I suggested to him that the American Ceramic Society might wish to publish it, he protested that it contained little new material, but in the main was merely an assembly of information from various sources. Nevertheless, it seemed to me that Dr. Preston's exceptional experience along these lines had enabled him to assemble, in a particularly useful way, information from sources not convenient for most glass technologists. In the belief that this paper will be helpful to others in our profession, I am transmitting it for publication.—L. T. Sherwood.

Presented at the Annual Meeting, American Ceramic Society, Toronto, Ont., February, 1930 (Glass Division).

[2] H. Insley, "Petrographic Microscope as an Instrument for Glass Technology," *Jour. Amer. Ceram. Soc.*, **11** [11], 812–28 (1928).

All polariscopes depend on the "double-refraction" (alias, "birefringence") of strained glass, for their working. But not all strained glasses are birefringent: it depends on the glass, and also on the nature of the strain.

Birefringence in glass is relatively slight: in most crystals it is vastly greater and can be studied with far greater ease. Consequently the petrologist commonly knows a great deal more about it than does the glass technologist. Literature on birefringence as applied to glass will be found in treatises on light and in treatises on crystallography or petrology.

The optical phenomena of crystals are adequately described in the standard textbooks of physics. T. Preston's Theory of Light is still the classic; an excellent treatise is R. W. Woods' Physical Optics; and many others are good enough. But these do not explain much about stresses and strains: they talk about crystal and optic axes.

Stresses and strains are discussed in special elaborate mathematical treatises. Love's Theory of Elasticity is the classic, but any one who can understand it will not accept a position as a glass technologist. Simpler accounts, sufficient for many purposes, are given in many engineering textbooks, frequently under the misleading title of "Strengths of Materials" or even "Theory of Structures."

The work most directly connected with our subject, done with a perfect grasp of both the optical and elastic phenomena, is the magnificent labor of Adams and Williamson, of the Geophysical Laboratory of Washington. The published results are a little scattered, in the *Journal of the Franklin Institute*, and elsewhere; and necessarily, though dealing specifically with strains in glass, the papers are written from the point of view of the expert and exclude all the elementary parts.

In England, Coker, Filon, and others have worked a good deal at the subject of birefringence produced by strain, or "photo-elasticity." Coker has rarely concerned himself with glass, but much of his work is directly relevant, and he has frequently gone to some pains to make the subject intelligible to the average reader rather than to the specialist. Filon's work has come oftener into the glass field, but usually retains a severely technical and mathematical air. It is, however, very illuminating, and probably Prof. Filon is thinking further ahead than any other writer on this subject.

If I fail to specify the work of the German writers, it is not because it is not excellent, but simply because the average glass technologist rarely reads German. There are a few good French writings on photo-elasticity (rarely connected with glass) and one or two Russian ones of which I have never been able to obtain more than abstracts.

On the present occasion I have set myself to the task of trying to explain much of the optical, and some of the elastic (stress and strain) phenomena, in non-mathematical terms. This may be difficult, but it is necessary, because, as I have said before, the glass technologist is usually a chemist, and nearly all chemists will admit either that they know no mathematics or that their mathematics is "rusty." Since the average glass-works engineer, and in fact, the greater part of humanity, is in the same fix, a non-mathematical treatment is essential. At the same time, in order that those (chemists, engineers, superintendents, or whatever they be) who are not so "rusty," may be able to see the mathematical connection, I have interposed here and there, in smaller type, some elementary mathematical work as an alternative to the purely descriptive material. I hope that in so doing, I shall not alienate any one's affections. Those who can read the mathematical work should do so: those who cannot, will yet find a coherent account without it.

I desire to discuss the general subject of strains in glass, the characteristic distributions of such strains, and the characteristic troubles they cause (*i.e.*, characteristic types of breakage, warping, etc.). I am more concerned with sheets, tubes, and bottles than with optical elements such as lenses and prisms. This is partly because so many more sheets and bottles are used, partly because the optical glass technologist is so interested in strained glass that he has a good working knowledge of the phenomena, and partly because Adams and Williamson have covered the ground already with characteristic thoroughness.

Explanation of Harmonic Vibration and Amplitude

Difference of Phase In Fig. 1, we have a square billiard table, without pockets, very smooth, and with perfectly elastic cushions. A network of squares, 64 altogether, is drawn on the table, and extends as far toward the cushion as the center of the ball can get. The ball is shown at the center, O, and it can travel as far as P before it hits the cushion.

John will hold the stop-watch, and when he says "Go," you will strike the ball, O, toward P, at such a speed that it covers each little square in 0.1 second, so that it takes 0.4 second to reach P. Then it bounces back, and goes to P' in 0.8 second more, and thereafter it keeps on going back and forth from P to P' for all eternity.

The ball is now said to be executing a "vibration:" that is, it is moving periodically and systematically. It is also executing a "harmonic" vibration, because its period remains constant. The "period" is the time from O to P, back to P' and then to O again. The distance, OP, is the "amplitude."

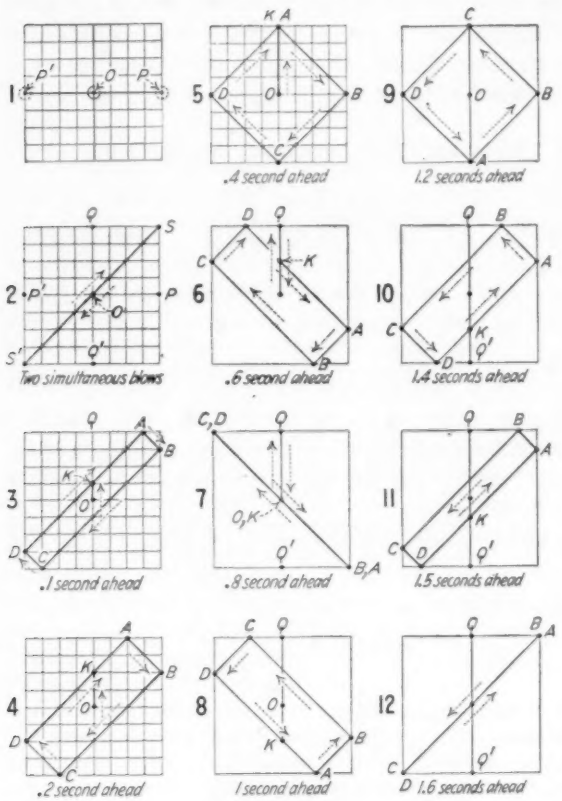
For the benefit of the mathematicians, it should be observed that although the motion is "harmonic" it is not "simple harmonic"; it is harmonic because it has a regular period, and therefore its motion can be expressed in a Fourier series; it is not simple harmonic because it cannot be expressed by a single term of a Fourier series. But we shall come back to that later.

We shall now stop the ball and set it central at O once more (Fig. 2) and when John says go, you will strike it exactly as before toward P, while at precisely the same instant I shall strike it toward Q.

The ball will then actually travel to S, and from S back to S', and execute a vibration thereafter between the corners of the table. If your blow alone had taken effect, the thing would have oscillated between P and P'. If my blow alone had taken effect, it would have oscillated between Q and Q', and at precisely the same speed, or with precisely the same period of 1.6 seconds. But as both blows took effect it goes from S to S' and back, and also with the same period of 1.6 seconds, though it has

farther to go. Its "amplitude" is now OS. In other words, our two intended independent vibrations have combined into one.

Now you are going to give me 0.1 second start. When John says go, I am going to hit the ball toward Q (Fig. 3). One tenth of a second later, when the ball is at K you are going to strike toward the right again. The ball will then move from K to A. Here it will rebound off the cushion to B, and the cushion at B will send it to C, and so on from C to D, and back to K. Afterward for all eternity it will travel around the rectangle $ABCD$, bouncing off each of the four cushions in turn.



FIGS. 1–12.

We shall now do the same thing, except that you give me 0.2 second start. The result is shown in Fig. 4.

In Fig. 5, you have given me 0.4 second start. The ball has reached Q and is just about to rebound toward Q' when your blow takes effect. The ball now goes around in a square, set diagonally in the square of the table. This is the result of giving me a quarter-period start.

In Fig. 6, you give me 0.6 second start. The ball reaches Q, returns as far as K, and then your mallet strikes. The result is a rectangular path of travel as shown.

In Fig. 7, you gave me 0.8 second start, the ball was back at the center headed south for Q' before you struck it. The result is that the ball vibrates from corner to corner in a single straight line, as in Fig. 2, except that the line is inclined the opposite way from NW to SE, instead of NE to SW. This is the result of giving me a half-period start.

In Fig. 8, I had a whole second start, and the ball was at K headed south before you hit it. The ball goes around the same rectangle as in Fig. 6, but it goes the opposite way round.

In Fig. 9, I had 1.2 seconds start. The ball reached A before you hit it. Then it went round the square $ABCD$. This is the same square as in Fig. 5, but "described" the opposite way round. This results from three-quarters of a period start.

In Fig. 10, with 1.4 seconds start, we get the rectangle of Fig. 4 once more, but described oppositely.

In Fig. 11, we are back to the shape of Fig. 3, save for the reversed directions, and in Fig. 12, with 1.6 seconds start we have returned absolutely to Fig. 2. This is the result of a whole period start.

Now if you give me 1.7 seconds, it will be the same as if you give me 0.1 second; we shall get Fig. 3 again, 1.8 seconds will be the same as Fig. 2, and so on. We have exhausted all the possibilities.

We are now going to tie our billiard ball to a string and suspend it over the table; we use a long, light string and suspend the ball over O, just clear of the table. We also remove the cushions.

When John says "Go," you strike the ball in the same direction (toward P) as before, and you strike just sufficiently hard to make it reach P. We now have a plumb-bob or pendulum, vibrating from P to P' and back again. So far, this is exactly what we had originally, but now the speed of the ball varies all the time. It comes up to P and P' very gently, and rushes through O at a great pace.

The motion though now seemingly more complicated is mathematically more simple. In fact we now have a "simple harmonic" motion.

The actual speed at O, and the "period" from P to P' and back to P, depends on the length of the string by which the ball is suspended. The longer the string the longer the period and the slower the speed. We shall adjust the length of the string till the period is 1.6 seconds as before.

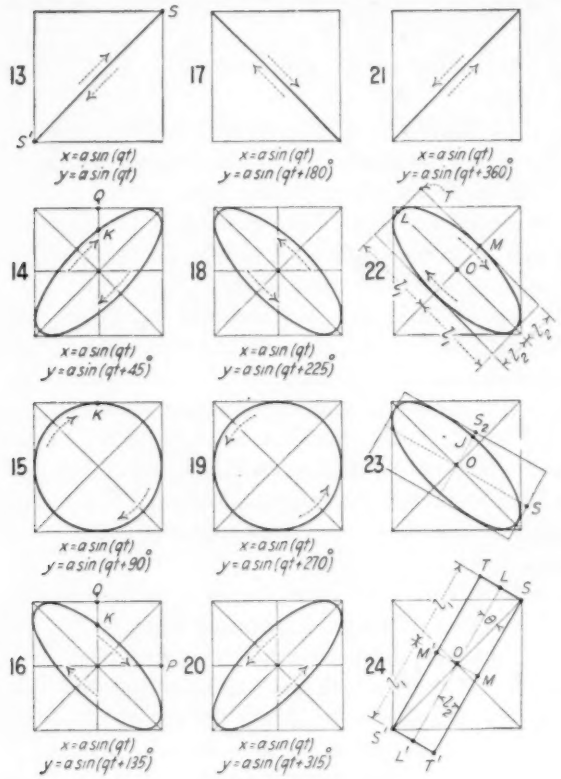
Then at the end of 0.2 second, the ball instead of being half way from O to P, is 0.7 of the way. At 0.4 second it has reached P. At 0.6 second it has returned only 0.3 of the distance from P to O. Then it gathers speed and at 0.8 second is back at O headed full speed for P'. It repeats the performance on the P' side of O.

Now let John say "Go," and you and I shall both perform with the mallets. The result is Fig. 13, a diagonal motion of the ball, with the same period of 1.6 seconds. The speed is greatest at the center and nothing at the ends. Two simple harmonic stright-line vibrations have combined into a single simple harmonic straight-line vibration.

Now give me 0.2 second start. The ball gets to K before you hit it, and then it follows the ellipse of Fig. 14. This corresponds to the rectangle of Fig. 4. But now we have a simple harmonic vibration, and then

we had a very complex "compound-harmonic" vibration. Mathematically an ellipse is a much simpler figure than a rectangle, because an ellipse is made of one line, and a rectangle needs four.

In Fig. 15 you have to give me 0.4 second start, or one-quarter period. To our great delight we find that the ball describes a circle, in the direction of the hands of a clock. This is the simple harmonic equivalent of the diamond-wise square in Fig. 5.



FIGS. 13–24.

Figure 16 shows the result of a 0.6 second start, and may be compared with Fig. 6.

Figure 17, with a half-period start, is the homologue of Fig. 7. We get a straight line from NW to SE.

Figure 18 is the same as Fig. 16, but described the other way round, *i.e.*, counter-clockwise.

In Fig. 19, we have the counter-clockwise circle corresponding to three-quarters of a period, or 1.2 seconds, start.

In Fig. 20, I get 1.4 seconds start, and in Fig. 21, I get a whole period, or 1.6 seconds, and we are back exactly to Fig. 13.

In all the cases from Figs. 13 to 21, we have simply "compounded" two vibrations of equal period, but in directions at right angles to one another. The difference between one figure and another is entirely a question of how much start I get. This is technically known as the "difference of phase."

In Fig. 1, when the ball is suspended as a pendulum, the motion thereof may be expressed mathematically as $x = a \cdot \sin(qt)$. Here x is the displacement of the ball to the right of O: a is the distance OP, technically known as the "amplitude"; and t is the time in seconds from the start; q is a measure of the frequency of the vibrations; the smaller

q is, the longer it takes the ball to go through its paces. Since a "sine" is always the sine of some angle, qt is an angle. q, in fact, is $360°/T$, where T is the periodic time in seconds, *i.e.*, T in our case equals 1.6 seconds.

Mathematicians rather like to write the whole thing as $x = a \sin\left(\frac{2\pi}{T} \cdot t\right)$, where 2π is written in place of 360°, *i.e.*, the angle is thought of as consisting of so many radians rather than so many degrees. This gives a certain "tone" of high society to the function, and makes the mathematician feel good, but it has to be converted back to degrees when one needs to do any serious computing. Therefore, in what follows, q will be written as $360°/T$ or $360/1.6$ seconds.

In Fig. 13, when we compounded two vibrations strictly in phase, the equations for locating the ball at any time are,

$$x = a \sin\left(\frac{360}{1.6} \cdot t\right) \quad y = a \sin\left(\frac{360}{1.6} \cdot t\right)$$

The printer who has to set this up will much prefer that I shall write q instead of $360/1.6$, so hereafter we shall do so.

Figure 14 is expressible mathematically as $x = a \sin (qt)$, $y = a \sin (qt + 45°)$.

Figure 15 represents $x = a \sin qt$, $y = a \sin (qt + 90°)$, and so on.

All the vibrations are of the form $x = a \sin qt$, $y = a \sin (qt + E)$, where E is the phase-difference, or "phase angle."

If $E = 0°, 360°, 720°$, the vibration is plane polarized /.

If $E = 180°, 360° + 180°$, etc., the vibration is plane polarized \.

If $E = 90°, 360° + 90°$, etc., the vibration is circularly polarized and clockwise.

If $E = 270°, 360° + 270°$, etc., the vibration is circularly polarized, counter-clockwise.

Resolving into Separate Vibrations

In Fig. 13, we saw that two straight-line vibrations in different directions could be compounded into a single straight-line vibration in an intermediate direction, provided the two vibrations were in phase. This new single vibration has exactly the aspect of a plain simple harmonic vibration; there is nothing to suggest that it is compounded of two. But, if we wish, we may consider it as being made of two vibrations; in mathematical language we may say that we may, if we wish, "resolve" it into two vibrations.

If s be the displacement of the ball from O toward S, we can define the movement simply by the one equation, $s = \sqrt{2}\, a \sin qt$. But we can equally well locate it by the two equations, $x = a \sin qt$, $y = a \sin qt$.

But if we wish to "resolve" the vibration SS' into two components, we are not compelled to choose the directions of x and y. For example in Fig. 24, we might imagine that when John said "Go," you gave the ball at O a good blow that would cause it to oscillate from L to L'. Simultaneously I give it a blow, not so hard, that would cause it to go to M and oscillate from M to M'. The net result is that the ball travels from S to S'.

In other words, there are various combinations of blows that can make the ball travel along the diagonal SS'. And if we find a ball oscillating

between S and S', we have no means of knowing whether it was started by a single blow along OS, or by two equal blows along OP and OQ, or by two unequal blows in some other directions. Thus it is open to us, if we wish, to regard the vibration as being made up of whatever combination best suits our purpose, that is, whatever is easiest for us to think about.

In Fig. 24, we regard the motion as being made up of a displacement along OL, and a displacement along OM. At any instant let the displacement be l and m, respectively. Then $l = OL \sin qt$. $m = OM \sin qt$. Or $l = (\sqrt{2}\, a \cos\theta) \sin qt$. $m = (\sqrt{2}\, a \sin\theta) \sin qt$. The parts within brackets are the respective amplitudes, and the suffix, $\sin qt$, defines the period and the fact that there is no "phase angle," *i.e.*, $E = 0$.

Now the same argument applies not only to the straight-line vibration of Fig. 13, but to any of the elliptical or circular ones. Once we have the elliptical motion established, there is no means of telling what particular combination of blows was used to start it.

Let us take Fig. 16, where you gave me 0.6 second start, and the blows were delivered first toward Q and then toward P. We have exactly the same ellipse in Fig. 22, described in the same clockwise direction, but produced by different causes. Here, at the word "go," I strike the ball from O to L, and at this point you strike a gentle blow, in the direction LT, of such a strength that if it had been delivered on the ball when stationary at O, it would have carried it to M. The ball actually does arrive at M, but on the curve from L to M, not from O to M, taking 0.4 second to do it. It goes around the whole ellipse in 1.6 seconds, the regular period. Note too that instead of giving me 0.6 second start, you gave me only 0.4 second.

It is not difficult to see that the same elliptical motion could have been produced in various other ways. In the directions of x and y, we needed two blows of equal intensity to produce equal amplitudes (so that the ellipse becomes contained in a square with sides parallel to OP and OQ), and a phase-difference of 0.6 second, corresponding to a phase angle of 135°. If the blows are delivered in the directions OL and OM, their intensities must be different, one greater and one less than previously, and the phase-difference is changed. We then think of the vibration as being contained in a rectangle as shown. If, as in Fig. 23, we decide to draw some other rectangle around the ellipse, we can find some suitable phase-difference and suitable intensities for the blows.

The mathematically-minded reader ought to work this out for himself, to determine precisely the suitable phase-difference and amplitudes in any particular case. I give, however, a brief and slightly simplified version, in order that there may be no hiatus in the story.

An elliptical vibration can obviously always be reduced to the condition of Fig. 22; that is, it can be considered as being compounded out of two straight-line vibrations, one along the direction of the major axis, and one along the direction of the minor axis,

the two amplitudes being unequal, and the phase-difference 90°, or $\pi/2$. We require, to find the amplitudes and phase-difference along another pair of axes inclined at an angle, θ, to the natural elliptic axes. Let us, for the purpose of this subsection only, call the major axis of the ellipse the axis of X, and the minor axis that of Y, as shown (Fig. M). We require the amplitudes and phase angles for the axes OL and OM. The vibrations along OX and OY can be expressed as

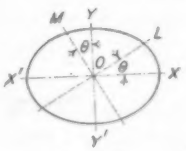


FIG. M.

$$x = a \sin qt. \quad y = b \sin (qt + 90°) = b \cos qt.$$

[NOTE: a here is the semimajor axis of the ellipse, not the length OP of Fig. 1. Forget all about the figures, except Fig. M, for the present.]

Along OL the x vibration resolves itself into a component $x \cos \theta$, while the y vibration contributes an element $y \sin \theta$. That is, $l = x \cos \theta + y \sin \theta = a \cos \theta \cdot \sin qt + b \sin \theta \cdot \cos qt$.

This may be written $l = R \cos \phi \sin qt + R \sin \phi \cos qt$.

Where $R = \sqrt{a^2 \cos^2 \theta + b^2 \sin^2 \theta}$ and $\phi = \tan^{-1} b/a \tan \theta$.

Hence $l = R \sin (qt + \phi)$

$= \sqrt{a^2 \cos^2 \theta + b^2 \sin^2 \theta} \cdot \sin \{qt + \tan^{-1} (b/a) \tan \theta\}$.

Here the amplitude is $\sqrt{a^2 \cos^2 \theta + b^2 \sin^2 \theta}$, and the same phase angle, as compared with the vibrations along OX, is $\tan^{-1} b/a \tan \theta$. In the same way the vibration along OM may be shown to be $m = \sqrt{b^2 \cos^2 \theta + a^2 \sin^2 \theta} \cdot \cos \{qt - \tan^{-1} (a/b) \tan \theta\}$.

This gives us the amplitude of the vibration, and its phase angle as compared with the vibration along OX. The phase angle that interests us, of course, is the difference of phase between (1) and (2), which may be obtained by subtracting the one phase angle from the other. It is instructive to check up on this and see what happens when $a = b$, the case of Fig. 15, or when $\theta = 45°$, but a and b are different, the case of Fig. 14. But I leave this to the readers who are so inclined.

Whether the reader understands the mathematical parts or not, it is necessary that he should understand the sequence of Figs. 13 to 21, that is to say, what happens to a plane polarized vibration (Fig. 13) as successively greater phase angles are introduced; how it passes through ellipses to a circle, then through other ellipses to a straight line at right angles to the first, and so on.

The problem may be looked at thus. In Fig. 13, we have a plane polarized vibration, that is a vibration in a single straight line. In Fig. 14, we have given it a little blow at right angles and started it swinging in an ellipse. The blow, however, would confer on the vibration some extra energy, if the length SS' remained unchanged. This would be easy enough in the case we have been talking about, where the vibrator is a billiard ball and you and I have mallets and can supply energy from outside. But we are now going to consider light vibrations, whose component parts we can re-arrange, but whose total energy we are powerless to alter. In such a case, if we give the "ball" a component at right angles to SS', we must reduce the amplitude of the SS' component. This, the reader will see, has happened in Fig. 14, and still more in Fig. 15. In Fig. 17, the SS' component has shrunk to zero, in order to provide the energy for a full-force vibration at right angles to SS'. The reader is

advised to meditate on these things before going further, for we are now going to talk a little about the constitution of matter.

Glasses and Crystals

Glasses are silicates that have failed to crystallize. This is the best definition I know of. If other substances fail to crystallize they are sometimes described as "vitreous" or "glassy" by analogy, but they are rarely called "glasses." Some glasses contain microscopic or even macroscopic crystals, and the mixture is still spoken of as a glass, but there is a tacit understanding that only the non-crystalline part is really glass, and that the whole body is spoken of as a glass only when, and because, the glassy constituent predominates. Volcanic lavas are usually partly glassy, partly microcrystalline. Some of the glasses of industry are similar, but the glasses we are generally concerned with are wholly glassy, devoid of even microscopic crystals. They may, conceivably, sometimes contain still smaller, ultra-microscopic ones, but that makes little difference to their optical behavior.

A crystal is characterized by the molecules thereof all being oriented one way, in a regular arrangement. A glass is characterized by the molecules all being arranged in a chaotic, higgledy-piggledy fashion, without any order. By a strange dispensation of nature, this complete chaos is optically equivalent to the most perfect regularity possible.

What Is Meant by Lattice A crystal is said to be "regular" when it belongs to the "cubic" or "equiaxial" system. This is not a treatise on crystallography, and the forms that can be assumed by a "cubic" crystal, such as cubes, brick-shaped pieces, octahedra, rhombic dodecahedrons, and so on, are described in many treatises and will not be described here. We are more concerned with the the molecular arrangement of "regular" or "cubic" crystals. If only one sort of atom is present, a material is very apt to crystallize in the cubic system. Many pure metals do this; so do the simple chlorides, bromides, etc., where, as the Braggs have shown in their work on X-rays and crystal structure, the metal atoms form a cubic lattice of themselves, and the halogen (chlorine, bromine, etc.) forms another cubic lattice of the same size as the first and interpenetrating it. For the moment, however, we are interested in the case of a lattice made of a single kind of atom.

Such a lattice can most simply be built of atoms arranged at the corners of cubes. That is, we can take a large number of cubes, all the same size, fit them smoothly together into a great block, divided as it were by three sets of cleavage planes (the faces of the cubes) and put an atom at each intersection of these cleavage planes. Figure 25 shows such an arrange-

ment, the pattern of the atoms being in squares. It is a plan view, but the pattern would look the same if viewed squarely from any of the sides.

There are other arrangements of the lattice possible without destroying its "cubic" nature. Such are the "face-centered cube" and the "body-centered cube," but for these see the works of Bragg and others. So far as glass is concerned, the variety of Fig. 25 is sufficient to illustrate our point.

Effect of Lattice on Light Transmission

The peculiar feature about such a crystal is, that if it be transparent at all, light may pass through it in any direction without its polarization being in any way affected. That is to say, if the light be coming up through the paper in Fig. 25, and its vibration be from N to S, on entering the crystal, it will still be N to S on emerging. If it were from E to W on entering, it would emerge E to W, and what is more significant, if it were NE to SW, or NW to SE, it would still get through unchanged.

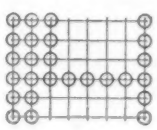


FIG. 25.

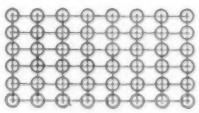


FIG. 26.

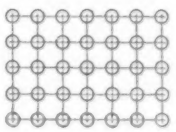


FIG. 27.

The reason for this is not difficult to follow. If we draw any two lines, at right angles to one another, but inclined at any direction to the N and S, through an atom of Fig. 25, the pattern of atoms along the one axis is exactly duplicated on the other. This perfect symmetry of the atoms (and their electronic linkages) makes it impossible for the crystals to affect the polarization of the light.

But in Fig. 26, we have taken the crystal of Fig. 25 and stretched it lengthwise along the axis of X. In accordance with a law of nature, well known to engineers, the longitudinal stretch is naturally accompanied by a smaller, but perceptible contraction sideways, along the axes of y and z. Therefore in the figure, I have shown the lattice contracted from N to S, though this does not affect our argument. All that matters is the fact that the lattice is no longer made of squares, but of rectangles. That is, as seen in this particular view. If we looked at the crystal from north or south, we should see a similar set of rectangles, while if we looked from east or west, we should see squares, though the squares would be smaller than in Fig. 25.

Now if, in Fig. 26, light is coming through the crystal, up through the plane of the paper, and vibrating from north to south, it would come through unchanged. This is because the structure of the crystal is still symmetrical to left and right of the vibration. Or again, if the light were vibrating from east to west, it would get through without its polarization being affected, and for the same reason. But the east and west vibration,

and the north and south vibration, would not get through the crystal equally rapidly, since the density of atoms is greater one way than the other.

Double Refraction But now let us put through the crystal a vibration oscillating in the NW to SE direction. Such a vibration will find the atomic structure so unsymmetrical that it will not come through unchanged. It will in effect "resolve" itself spontaneously into two components, one in the north to south direction, the other in the east to west direction. These two vibrations will initially be in step or in "phase," but they will gradually get out of phase, the phase-difference increasing continually as the light travels through the crystal. When the light emerges into air again, the phase-difference ceases to change; it remains as it was when it left the crystal. What this amounts to, depends on how thick the crystal is. The light, which entered the crystal plane polarized, gradually developed elliptic polarization, circular polarization, and so on, and went through all the gamut of Figs. 13 to 21, or as many of them as the thickness of the crystal required. If the crystal were thick enough, it would go through the whole series of changes several times. The crystal is now "doubly-refracting."

The same fate would befall a vibration that wished to traverse the crystal from N to S, along the axis of y, unless it were beating (oscillating) parallel to the axis of x or y. If it were inclined to these axes, it would get out of phase and emerge elliptically polarized.

But the same fate would not befall a vibration that traversed the crystal from east to west, because when the crystal is looked at from this direction, it still consists of squares, not rectangles. Light traveling in that direction will escape unaffected.

Optic Axis The east to west direction, therefore, or the x axis, is spoken of as the optic axis of the crystal. The optic axis is defined as the direction in which light can travel without having its polarization disturbed. There is only one such axis in the present crystal which is therefore said to be "uniaxial:" the crystallographer often refers to such crystals as "tetragonal."

To make the crystal of Fig. 25 into that of Fig. 26, we stretched it along the x axis. Now keeping it under tension along the x axis, let us also stretch it along the y axis. Only the z axis remains free of tension. The appearance of the crystal in plan view, that is, the view corresponding to Fig. 26, becomes less rectangular and more square. As the tension along Y is gradually increased, a point is reached where it equals the tension along X (Fig. 27). At this moment the rectangles have become squares again, though bigger than the squares of Fig. 25. Further increase of the Y tension causes the rectangles to become elongated in the Y direction.

The optical effects are interesting. As the Y tension is applied, the double-refraction effect, on light traveling up through the paper, becomes less. That is, the phase-difference is less for the same thickness of crystal. When the Y tension is equal to the X tension and the pattern of the atoms is once more a net of squares, the double refraction disappears entirely. It reappears (with the sign changed) when Y is increased beyond X. These points are of the greatest importance to the glass technologist.

A queer thing happens to the optic axis. As soon as the Y tension is applied, the optic axis splits in two. Whereas it was previously coincident with the x axis, there are now two optic axes, V_1 and V_2, slightly off the x axis, and inclined to it (Fig. 28). They lie in the plane of the axes x and z, and are at right angles to the axis of y. The crystal has become "biaxial;" the crystallographers sometimes call it "rhombic." As the Y tension increases, the optic axes diverge more and more on each side of the x axis, and begin to approach the z axis. When the Y tension becomes equal to the X tension, the optic axes reach the z axis and disappear into a single axis. The crystal is uniaxial once more.

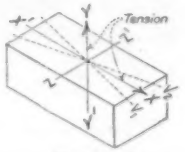


FIG. 28.

Further increase of the Y tension separates the optic axes in the plane of ZY, the optic axes gradually starting from the Z axis and approximating to the Y axis when the Y tension becomes exceedingly great.

The optic axes have the same property as before. Light can travel down them without its polarization being affected. If we look down an optic axis, the pattern of the atoms looks like squares. In any other direction it has a rectangular or rhombic air. Note that an optic axis is a *direction*, not a particular line.

It is not necessary for the glass technologist to understand much about optic axes. It is merely necessary that he should understand that two equal tensions at right angles will cause the glass to appear free from double refraction. And that two unequal tensions will not look so bad as the greater of the two would by itself. This is a sad handicap in practical work, and the investigator of double refractions has to be on his guard.

I have included this brief section on the optic axes, in order that those who shall hereafter read about them in textbooks of physics or petrology, or have already read about them, may see the connection between crystallography and photoelastic phenomena, the resemblance between crystals and strained glass.

Before leaving this section, I may observe that the crystallographer recognizes, besides cubic, tetragonal, and rhombic crystals, two others of still greater asymmetry, the monoclinic and triclinic. But these do not concern us as glass technologists, since they are optically much like the rhombic system, and differ mainly in the fact that the optic axes are apt to be very different for light of different colors, which does not happen with glass so far as I know. The crystallographer has also another sort of crystal, the hexagonal, which is uniaxial, and behaves much like a tetragonal one as far as its optical features are concerned.

As a matter of interest to the glass man, we may add that quartz crystallizes in the hexagonal system, orthoclase (potash) feldspar in the monoclinic, and plagioclase (lime–soda) feldspar, in the triclinic. Quartz (glass sand), however, has a spiral arrangement of its molecules, so that it has additional strange optical properties which we do not wish to discuss here.

Cubic Lattice Effect in Glass

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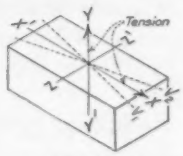

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Cubic Lattice Effect in Glass

Now we have been talking hitherto about the arrangement of atoms

in a crystal, and how this affects the optical properties of a crystal. But glass is not a crystal, and its atoms and molecules are arranged, as we have already said, in utter disarray. So chaotic, however, is the disorder that it behaves, if well annealed, like a crystal of the regular (or "cubic") system. This is because, on the average, the molecules are oriented in all directions in about equal numbers, and if one molecule wants to introduce a phase angle, another wants to introduce an exactly opposite one; in other words, the statistical average orientation of the molecules is nil. This statistical result is totally different in origin from the regularity of a cubic crystal, but the optical effect is the same, and it helps to clear one's mind if we think of glass, when well annealed, as being made of a number of atoms arranged in a cubic lattice, and, when it is strained, as having its atoms distorted into a tetragonal or rectangular lattice.

Light and Light Transmission

There is an experiment the student ought to make, which is very enlightening at this point, although, for the sake of my mathematical readers, I ought to add that it is not a precise mechanical analogue. The experiment consists in taking a good straight rod of wood, fairly flexible and of uniform grain, clamping one end and making the other end vibrate. First, get a rod of a round or square section. Such a rod is "equiaxial" in section, and corresponds to a cubic crystal. If we pull the free end of the rod to one side and let it go, it will vibrate in a straight line, and no matter what the direction of the displacement may be, it will still vibrate in a straight line, and with the same frequency.

Now take a rectangular or elliptical rod. If displaced in the direction Y, Fig. 29, it will vibrate, with a slow period, along the direction YY'. If displaced along the X axis, it will vibrate along the axis, but with a quicker period. If, however, we displace it in some cornerwise direction, it will not vibrate in a straight line at all, but in an elaborate curve, perhaps a figure of 8, or more probably something more complicated. Mathematically the curve can be accounted for by saying that the cornerwise vibration splits into two independent ones, one along XX', and one along YY', having different frequencies. Physically, as distinct from mathematically, since each particle of the rod can be in only one place at one time and headed in only one direction, there is really only one vibration, but it is exceedingly complex to our minds when considered as a single vibration, and exceedingly simple when considered as two. No doubt the rod itself, not being afflicted with the uneasy conscience of a mathematician, finds the single vibration perfectly easy.

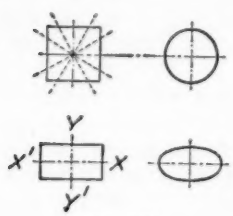


FIG. 29.

It shall be noted that the complicated figures described by the end of the rod are caused by the compounding of vibrations of unequal frequency. This results in more complexity than in the cases we are studying in connection with light, where we have always retained a single frequency (q) and merely changed the phase angle. This has confined our figures to straight lines, ellipses, and circles, a limited selection of conic sections.

Those who have half an hour to spare may learn more about it by turning to some encyclopedia on the subject of Lissajou's figures.

It is well worth the time of the mathematically minded student to plot a number of these curves from their equations. All that is necessary is to substitute $2q$, $3q$, etc., for q in the y equation of Figs. 13 to 21.

Now I have said that in the case of the rod, the mathematician, or even the man in the glasshouse, finds it easier to think of the vibration as consisting of two straight-line components traveling down the rod at unequal speeds, while the rod itself no doubt does not think of it that way.

Similarly, in the case of a light vibration entering a crystal or strained piece of glass and undergoing double-refraction, the whole phenomena become very simple if we regard the vibration as being composed of two straight-line vibrations, parallel to the directions of the greatest and least tensions. It is usual for a writer to state, more or less categorically, that "light, on entering a crystal or strained piece of glass, is split into two components," but the splitting occurs in the mind of the writer rather than in the glass. We ought to say "may be regarded as splitting into two components."

I do not want, however, to dogmatize on this point, for I do not know what the light really does do. I have decided, in view of the quantum theory and the Schrödinger wave-mechanics, that I do not know what light is. I have always known that I did not know what matter was. Therefore it seems unlikely that I should understand what would happen to light on entering matter. Fortunately a glass technologist can live with double-refraction and even make use of it, without understanding its innermost nature.

Refractive Index

Light, when traveling in space, covers some 186,000 miles a second. When traveling in glass, its rate falls to something like 120,000 miles a second, or less with the dense glasses. In celluloid or water it makes about 140,000. The ratio 186,000/120,000 is called the refractive index of glass. This is commonly indicated by the symbol, μ. It is a good thing that light does slow down on entering glass. It is this that makes telescopes and microscopes possible. Moreover, glass would be totally invisible, except for dust on its surface or defects inside it, if light did not slow down on entering it. That would make it pretty difficult to handle in glass plants, except those where "seeds" and dust were plentiful.

Now when light enters strained glass it behaves as if split into two components, one of which travels slightly faster than the other; perhaps one vibration travels at 120,000, and the other at 121,000 miles per second. Consequently the two vibrations at once begin to get out of step, or out of phase, and the further they go the more out of phase they get.

Double Refraction or Birefringence

We are expressing the same thing in a different way when we say that the glass behaves as if it had different refractive indices for light vibrating parallel to OX and parallel to OY. We would call them μ_x and μ_y. μ_x is the index of refraction, and $\mu_x - \mu_y$ is the double refraction (or birefringence) of the glass at this point, for light traveling along the axis of z. The present writer commonly writes $\tilde{\mu}$ as short for $(\mu_x - \mu_y)$. $\tilde{\mu}$ means "difference of the two μ's."

When we examine a piece of glass in a polariscope, we are hunting for this quantity $\tilde{\mu}$, or $\mu_x - \mu_y$. What the polariscope actually shows is the phase-difference (ϵ) by which one vibration gets ahead of the other on its way through the glass. ϵ is proportional to $\tilde{\mu}$ and also to the thickness of the glass. The number of wave-lengths by which one vibration gets ahead of the other [redacted] $\tilde{\mu} \cdot t/\lambda$. Where n is the number of wave-lengths of phase-difference, t the thickness of the glass, and λ is the length of a single wave of light. t and λ must both be in inches or both in centimeters.

For example, let $\tilde{\mu} = 0.0001$, $t = {}^1/_4$ inch, λ (for yellow light) = about ${}^1/_{50,000}$ inch. Then $n = 0.0001 \times 50{,}000/4 = 1.25$ wave-lengths.

This corresponds to a phase angle (ϵ) of $1.25 \times 360°$ or 450°, but we prefer to think now of wave-lengths of phase-difference.

Now a difference of refractive index of 0.0001, one unit in the fourth decimal place, seems very little, but as a matter of fact it is far more severe than is generally met with, and corresponds with a stress of about 4 tons/sq. in. Values of one-tenth this amount (0.00001) are common in the general run of glassware, and correspond with stresses of about 1000 lbs./sq. in.

Construction of Polariscopes

In Nature Nature provides a good deal of polarized light herself. Light coming directly from the sun or from a candle or electric lamp is not polarized; the vibrations are in all directions, but nearly all reflected light is more or less polarized. Light reflected obliquely from a polished wooden table top, or from a piece of glass, is partially polarized. The blue light of the sky is also largely polarized, especially from those parts of the heavens that are at right angles to the sun. Light is also partially polarized when it passes obliquely through glass or water,

so that fishes and factory workers live partly in polarized light. Light, however, is not so completely polarized by transmission as by reflection.

Simple Form The simplest form of polariscope we could make would probably be that shown in Fig. 30. We take a rectangular piece of glass, A, and prop it up at an angle of 36° or thereabouts. The direction of the light is shown. We then stand a piece of glass, B, on its edge, also inclined at 36° to the direction of the light. It will improve matters if the element A consists of several thin sheets of glass laid together, and also if B is made of several sheets. If now we look through B and A toward the light, the field will appear comparatively dark, and if a suitable piece of strained glass be put between A and B, it will show double refraction.

FIG. 30.

It is not essential that the angle be exactly 36°. The best angle is $\cot^{-1}(\mu)$, but the reason for this may be discovered in textbooks of physics.

The polariscope mentioned above, however, using transmitted light, is rather imperfect, because the light does not become wholly polarized. We could use the same instrument as in Fig. 31, reflecting the light first from the left-hand plate and then from the plate on the right. This makes the light path a bit complicated, but it gives better optical results. When the reflection method is used, a single sheet of black glass is just as good as several thicknesses of plain glass.

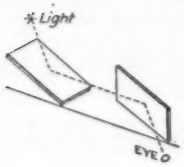


FIG. 31.

Reflectors and Diffusers A type of polariscope frequently used is shown in Fig. 32. The glass plate or plates, A, are used as reflectors, enclosed in a box to keep out extraneous light. One or more electric lamps are used as a source of light, and one or more diffusers, D, of ground glass, opal glass, or tracing paper, are interposed between the lamp and the reflectors, A. This is in order to illuminate the whole field as evenly as possible. The diffusers even up the light; the reflectors polarize it. The sheets, B, are set parallel to those of A, and we look through them, as shown. Very good work can be done with such an arrangement, although the element B is far from perfect.

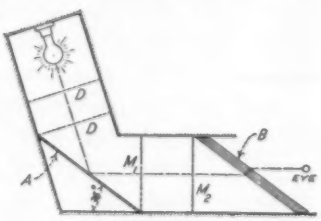


FIG. 32.

Analyzer For this reason the plates, B, are commonly replaced by a nicol prism, element A remaining as before. This arrangement of a reflecting plate for the polarizer and a nicol prism for the analyzer is the most usual arrangement in glass technology practice.

A better arrangement, so far as perfection of polarization is concerned, is to use two nicol prisms, one for the analyzer and one for the polarizer. This, however, is practical politics only when the specimen to be examined is small, or when one is content to examine a very small part of a specimen at a time, for nicol prisms are invariably small, nature not having provided a sufficient amount of large crystals of calcium carbonate (Iceland spar) of good quality. The two-nicol arrangement is used in the petrographic microscope, in saccharimeters, and so on.

The construction of a nicol prism depends on the fact that if light has to escape from a medium in which it is traveling slowly (one with a high refractive index) into one where it can travel more quickly (one with a lower refractive index) it will not succeed unless it hits the interface fairly squarely. The degree of "squareness" that is necessary depends on the difference of the refractive indices of the two media. If the obliquity is too great the light is totally reflected.

In Fig. 33 is shown a nicol prism of the square-ended type. It consists of two triangular pieces of calcite, *A* and *B*, cemented together with a thin layer of balsam or copal at *C*. Light enters at *P* and splits into two vibrations polarized in two directions at right angles to one another, and one of them traveling much faster than the other, for calcite is highly birefringent. One of the calcite's refractive indices is very close to that of the balsam while the other is much higher. When the swifter-traveling vibration reaches the balsam face at *Q*, the change of speed is not very great, and it goes through with very little difficulty. But the slower traveling vibration finds the change of refractive index too great; it is totally reflected and lost at *S*.

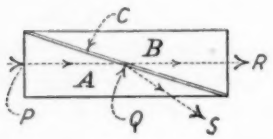


FIG. 33.

Crossed Nicols There are other polarizing devices known, but only nicol prisms and glass plates are commonly used. For all practical purposes the polarizer and analyzer are kept crossed, that is, the analyzer is set to reject the light that the polarizer sends forward. When the things are crossed, the field appears as dark as possible.

Both nicol prisms and glass plates produce plane polarized light. As we have seen, in the sections on crystal structure, plane polarized light is not affected by its passage through the "crystal," if it is vibrating parallel to one of the principal tensions. To get a true picture of the birefringence of the "crystal," we must get the nicols at 45° and −45° to the tensions.

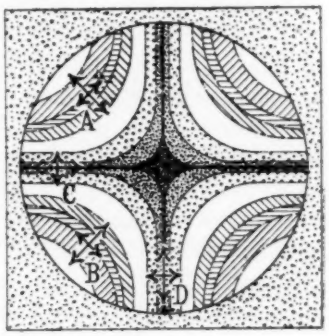


FIG. 34.

But if we examine a whole piece of glass at once, the tensions are apt to be oriented in different directions in different places. In Fig. 34, for instance, we have a circular disk of glass that was cooled too rapidly and

is therefore strained. We put it between our crossed "nicols," and we find a black cross on an otherwise light and colored specimen. The black cross is the same color as the blackness of the field before the specimen was introduced but it does not mean that the stresses are zero in the cross. The stresses at C and D are no different in amount from those at A and B, but we have so set our nicols that the polarizer gives light vibrating parallel to the stresses at C and D, and therefore at these places no "phase angle" is set up in the light. On the other hand, the light is split into two components on entering the strained glass at A and B.

The investigator must be careful in examining large sheets of glass or interpreting the results, that he does not get the nicol parallel to the stresses and so overlook the stresses altogether.

The black lines caused by the stresses being parallel to the axes of the nicols are called in technical jargon, isoclinic lines.

The same picture (Fig. 34) also serves to illustrate the point we have mentioned before, namely, that at the center there is a considerable black area which might, as far as the optical evidence goes, imply that the center is free from stress. Actually, the center is under the severest tension of any part, but as the tension is equal in all directions, it appears to have vanished in the polariscope.

Circularly Polarized Light So far as the "isoclinic" black lines are concerned, they can be eliminated, and one source of confusion abolished, if we use circularly polarized light. In practice, the simplest way to attain this is to begin with plane polarized light and convert this into circularly polarized light by means of a thin plate of mica. Mica, like calcite, is doubly refracting, and it can be split into sheets giving a quarter wave-length of relative retardation (corresponding to $E = 90°$). This is set with its vibration axes at 45° to the axes of the nicol's vibration, and we get circularly polarized light. In Fig. 32 this would be set at M_1.

A precisely similar plate would be set at M_2, and so arranged as to compensate for the first, *i.e.*, to introduce a relative retardation of $^1/_4$ wave-length in the opposite direction. That enables the nicols to stay crossed.

When the circular disk of Fig. 34 is now introduced between M_1 and M_2, it will have lost its black cross; the picture will consist of a black center surrounded by concentric bands of color. This gives a truer idea of the stresses, inasmuch as they are symmetrically arranged around the center. But the picture is still imperfect, for the black spot remains in the center, suggesting a minimum stress where there is actually a maximum, and moreover, the polariscope, like the previous one, does not distinguish tension from compression.

Most Useful Polariscope for Glass

Babinet Compensator The most useful form of polariscope I have yet discovered is the Babinet compensator. The compensator proper consists of a pair of quartz wedges cemented together and placed in front of the analyzing nicol. I do not wish here to enlarge on the construction of the instrument (of which a brief account will be found in most textbooks on optics) but the net effect is, when the nicols are crossed, to replace the dark field by a striped one. In the middle of the field is a vertical black line, and this is flanked systematically by colored ones (Fig. 35).

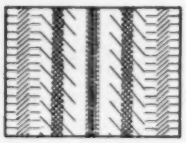


FIG. 35.

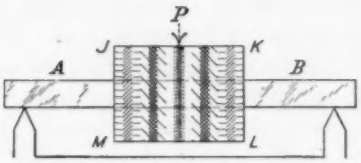


FIG. 36.

In Fig. 36, AB is a piece of glass resting on supports near the ends, and $JKLM$ is the part of the field visible through the compensator. If the glass is well annealed, the field is the same as in Fig. 35, although the glass cuts across the middle of it. Now, however, if we squeeze the glass endwise in the direction AB, the lines in the compensator will move to one side, say to the right (Fig. 37), the amount of the displacement being proportional to the stress.

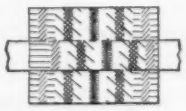


FIG. 37.

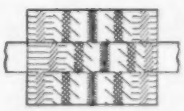


FIG. 38.

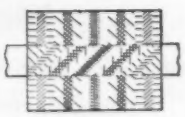


FIG. 39.

If we subject the glass to tension along AB, the lines in the compensator will move to the left (Fig. 38), while if we put our finger on the glass at P, and try to bend the glass, the appearance of the field becomes that of Fig. 39, the lines of the field tilting. This is because the effect of bending the specimen is to put the topmost layers of the glass in compression and the lowermost into tension; so the top part of the Babinet compensator lines moves to the right and the bottom part to the left.

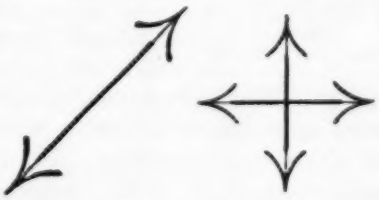
This sort of polariscope is very useful in glass work, because it so readily decides between tension and compression, and so accurately measures the amount. In dealing with large sheets of glass, of course, there is one point that must be watched. A tension in the horizontal direction has the same effect optically as a compression in a vertical direction. Further, the old difficulty remains, that two tensions at right angles neutralize one another. No polariscope can be trusted for detailed information in the hands of thoughtless persons.

Sensitive Tint Plate Mention should be made of the "sensitive tint plate." This is a thin plate of transparent colorless crystal (it may be mica, or quartz, or selenite), placed in front of the analyzer, with its axes of vibration set at 45° to the axes of the nicol. It is of such a thickness that light of medium wave-length (yellow-green) is thrown out of phase one complete wave-length and is extinguished. But violet-blue light is more than a whole wave-length out of phase and partly comes through. The orange-red light is less than a wave-length out of phase, and also partly gets through. The combination of colors from the two ends of the spectrum, without any of the central parts of the spectrum, produces a purplish color.

If now a specimen of strained glass be introduced, the strain being very slight, it will have the effect of increasing the phase-difference slightly or of reducing it slightly. If it increases the phase-difference, yellow and green light will begin to come through in addition to the violet-blue, but some orange and red will be abstracted. The change of tint is very noticeable. If on the other hand, the phase-difference is diminished, yellow and green light will begin to come through just as before, in addition to the orange and red, but some of the blue will be abstracted. Again the change of tint will be very noticeable. Tint plates are useful only for very slight strains.

Mathematics of Polarization of Light

I give herewith a tracing of the light through a polarizing nicol, through a strained piece of glass, and through the analyzer. We will have the "nicols" crossed and the glass with its tensions at 45° to the nicols.



(1) Let us suppose the light passing the polarizer is polarized NE and SW as in Fig. 13. It may be represented by the two components $x = a \sin qt$, $y = a \sin qt$.

(2) It enters the glass and the x and y vibrations travel at unequal rates and acquire a phase-difference, ϵ. The further they travel in the glass, the greater ϵ becomes. When the light emerges into air again we get $x = a \sin qt$, $y = a \sin (qt + \epsilon)$. This is an elliptical vibration of some sort.

(3) The light now comes to the analyzer. The elliptical vibration may be resolved into two components, one SS' in the initial direction (this will be rejected or "extinguished" in the analyzer) and one PP' able to get through the analyzer.

The amount of the P vibration is $p = x \cos 45° - y \sin 45° = x/\sqrt{2} - y/\sqrt{2}$

or $p = a[\sin qt - \sin (qt + \epsilon)]/\sqrt{2}$

$= a\,[2 \cos (qt + \epsilon/2) \sin (\epsilon/2)]/\sqrt{2}$

$= \sqrt{2}a \sin (\epsilon/2) \cdot [\cos (qt + \epsilon/2)]$

All that interests us is $\sqrt{2}a \sin(\epsilon/2)$, the amplitude of the light that gets through. The light that is rejected by the analyzer, *i.e.*, the S component is

$$s = x \cos 45° + y \sin 45°$$
$$= \sqrt{2}a \cos(\epsilon/2) \sin(qt + \epsilon/2), \text{ whose amplitude is}$$
$$\sqrt{2}a \cos \epsilon/2.$$

Now if our ball, whether it be on the billiard table or on the string, has to double its amplitude while its frequency remains unchanged, it has to travel twice as fast and its kinetic energy is quadrupled. In other words the energy or "intensity" of a vibration is proportional to the square of the amplitude.

Hence the intensity getting through the analyzer is proportional to $2a^2 \sin^2(\epsilon/2)$ and the intensity rejected by the analyzer is proportional to $2a^2 \cos^2(\epsilon/2)$.

The sum of the two is proportional to $2a^2$. This, of course, is the same as the intensity that came through the polarizer in the first instance.

The proportion of light that gets through is

$$\text{Light passing the analyzer/Light passing the polarizer}$$
$$= 2a^2 \sin^2 \epsilon/2 \div 2a^2 = \sin^2 \epsilon/2$$

This varies all the way from nothing to 100%.

If $\epsilon/2 = 90°$, *i.e.*, if $\epsilon = 180°$, everything comes through. If $\epsilon = 0, 360°$, etc., nothing comes through.

In terms of light-waves, if the phase-difference is an odd number of half wave-lengths, everything gets through; if it is an even (*i.e.*, 2, 4, 6, ...) number of half wave-lengths, nothing gets through.

Nature of Stresses in Glass

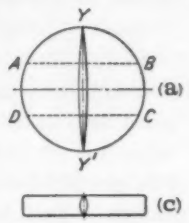
We have now discussed the nature of photoelastic phenomena: that is, polariscopic phenomena in strained glass. It remains to consider the nature of the stresses to which glass is subjected under various circumstances.

Annealing Strains Practically speaking, the only strains that have been much written about are those due to defective annealing. This is only a fraction of the whole subject, because glass breaks from a great variety of causes besides poor annealing, but we shall deal with annealing strains first. This part of the subject is, from the mathematical angle, vastly more complicated than the other, the purely optical end of the matter. It involves the whole theory of elasticity and of the conduction of heat. We shall not include any mathematical work here. The work of Adams and Williamson, already cited, and that of Hampton (*Trans. Op. Soc. London*) may be consulted by those who wish to go somewhat deeply into this subject.

The most typical of all annealing strains are those that arise from the fact that the outside of the glass must cool before the inside. I am not referring to the inside of bottles, but to the interior of the glass substance. In a cooling sphere for instance, the center is hotter than the surface. Heat has to be given up by all parts of the sphere. The outer surface can get rid of it readily by passing it on to the air or surrounding medium,

but the center can only get rid of it by passing it on to the outer layers, and these will not accept it unless they are cooler than the center.

The result is that the surface being cooler than the center tries to contract over it. Probably at this stage of the proceedings the glass is above the annealing range and can flow slightly so that no stresses are set up. By degrees a steady temperature régime is established, the center being about 50° hotter than the outside. Now the glass "sets." As long as the center is 50° hotter than the outside all is well, and we may reach almost room temperature in this condition. But finally the whole sphere, center as well as outside, has to reach room temperature. But the center must then try to contract, and in doing so it pulls inward on the exterior. The surface of the glass has a peripheral compression, while the center has a tension in all directions. These stresses are caused by the disappearance, at room temperature, of a temperature gradient that existed in the sphere when it was at the annealing heat.



FIGS. 40*a* AND 40*c*.

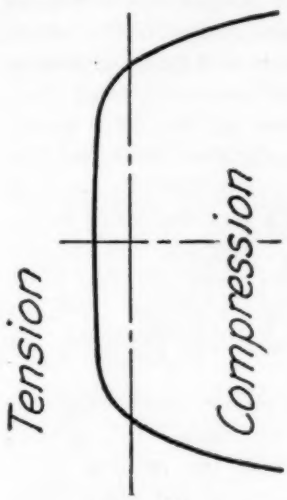


FIG. 40*b*.

A similar condition obtains when we cool a disk, as in Fig. 34 or Fig. 40*a*. If such a disk be split by a diamond along YY', the two parts will bow slightly, and if the horns, Y and Y', are brought into contact the center will show a slight gap. This is hard to detect except with a very large disk, but it is there. The stress distribution along YY' (before cutting in two) would be somewhat as in Fig. 40*b*. It represents the stresses in the fibers (if I may use the term) severed by the diamond cut. Figure 40*c* represents an edge view of the disk. After cutting along YY', there is a tendency for the crack to be bowed open also, as seen in edge view, but of course the amount is very slight owing to the stiffness of the glass. Let us, instead of cutting the disk down YY', cut out the piece $ABCD$ and examine it in the Babinet polariscope. The compensator's straight lines are bent into parabolic arcs (Fig. 40*d*), showing that in the center of the thickness the glass is in tension, while both surfaces are in compression.

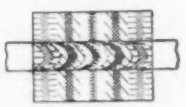


FIG. 40*d*.

The disk is a particular case of a sheet or plate. The stresses in sheets and plates generally are of this type, though often complicated by additional stresses, which may arise through uneven heat-

ing of oven floors, glass extra thick in certain places, and so on. All ordinary commercial plate and wire glass shows strains through the thickness of the type of Fig. 40*d*. These are not so serious (as far as breakage in use is concerned) as the heavier strains of Fig. 40*b*, which also are invariably present as far as I know.

Glass rods have a radial tension in the center and a peripheral compression at the outside, like the sphere. Glass tubes are more important. Since heat cannot escape to any appreciable extent from the air inside the tube, this air immediately heats up and remains hot while the glass "sets." The temperature is greatest at the inner face of the glass, and on cooling we get a peripheral tension near this face. There is, of course, a compression in the outer face. Such glass tubing as I have examined shows these strains as very pronounced. Boiler gage glasses break when scratched on the inside, though they will stand some battering on the outside.

Bottles tend to have the same strains as tubes in their side walls, and somewhat the same stresses as disks in their bases. Most of the bottles I have examined have, however, been far better annealed than the average glass tubing.

All articles are most readily annealed when they are free from sudden changes of section. Thin ware anneals more rapidly than thick, but thin parts of an article bordering on a thick area are apt to be badly strained. Bottles are often of uneven thickness, which is a very weakening factor.

Before leaving the subject of annealing strains, I may add that the time required by a sheet to anneal thoroughly, or to a given standard of excellence, is theoretically proportional to the square of the thickness.

As to strains other than those due to annealing, there are many and important ones.

Strains Produced in Polishing Glass is subject to very severe strains in grinding and polishing. In grinding plate glass, which is imperfectly annealed at best, the removal of $^1/_8$ inch from a surface grinds off a zone of compression and redistributes the stress in the interior. After the glass is ground and polished on one side the glass tends to be concave on that side. This is corrected when the other side is polished.

Moreover, when glass is ground with sand or emery or other abrasive, the surface is fissured in all directions with microscopic flaws, some of which are wedged open with tiny particles of glass débris or other material. This introduces severe strains, readily visible in a polariscope when optical glass (plate glass is always strained) is examined edgewise. These strains disappear in polishing,[3] but while they last they tend to make the glass convex on the ground face.

[3] Twyman, *Proc. Opt. Conv.* (1905); Preston, *Trans. Opt. Soc.* (1920–21).

Polishing generates a lot of heat and makes the top surface of the glass hotter than the bottom while the operation lasts. Much heat goes through the glass into the iron deck. The temperature gradient tends to cause cracks to open on the lower face of the glass. When the polishing ceases, the temperature gradient begins to reverse, heat being given back by the deck to the glass. This stretches the top face of the glass and while the glass is cooling, after polishing, cracks tend to run along its upper face. Of course in both cases, the crack soon goes completely through the thickness.

Furthermore, polishing is rarely uniform over the surface and the heating of the upper face is apt to be somewhat uneven. This is also a cause of much straining and consequent breakage.

Sheet glass is commonly taken from the leer somewhat too warm and piled in racks. It may then cool very unevenly on the two faces and is apt to break. Afterwards, if it does not break, it may be used in glazing windows, and the sun may beat on one part and heat it, and not on another. The shaded part may be thrown into tension and crack.

Optical glass is annealed with great care. A very fine lens is made with great circumspection, and completely free from strain. It is then glazed or "bezzelled" into its mount and the metal cramps it and strains it.

Photoelastic Constant

The strains that cause breakage in glass form a big subject, and I am concerned here primarily with the use of the polariscope in detecting strains, not with the subject of strains generally. Therefore I have treated the latter part of the subject somewhat sketchily. I have dealt with some aspects of it more thoroughly in the *Journal of the Society of Glass Technology*.

One thing we ought to define before we go, and that is, the "photoelastic" constant.

If we take a piece of glass one centimeter thick and stress it with a tension of 1 kg./cm.^{2}, a certain phase-difference is visible in the polariscope. With 100 kg./cm.,^{2} the phase-difference is 100 times as great. If we look through glass 10 cm. thick, the phase-difference is ten times as great. Different glasses vary somewhat in their photoelastic properties, but generally 1 kg./cm.^{2} produces about $^1/_{200}$ of a wave-length phase-difference for each centimeter of thickness, in the case of ordinary commercial soda-lime glasses.

A phase-difference of one wave-length per inch thickness of glass is introduced by some 1000 lbs./sq. in. of stress. Stresses of twice this amount are sometimes found in practice.

Monochromatic and White Light

In all the discussions hitherto we have assumed that we were dealing

with light of a single wave-length, except in the case of tin plate. In practice, however, white light (daylight) or an approximation to daylight (the electric filament) is far more convenient than sodium flames or other sources of monochromatic light, and white light is, or behaves as if it is, composed of a great variety of wave-lengths. Thus instead of having a single q to deal with, we shall, if we use white light, have many.

In dealing with monochromatic light, all that can happen to it in the polariscope is that its intensity may be changed. The process of changing the intensity may be a little complicated, but after passing the analyzer and coming to the eye, the light appears in no way different from what it did originally. There is merely more or less of it; its quality is the same, but its quantity changes. With crossed-nicols and no specimen, there is no light passing the analyzer. When we put in a specimen and start to strain it, light begins to pass the analyzer. As the strain increases, more and more light passes the analyzer until a maximum, the full intensity of the beam of light, is reached. Thereafter increase of strain begins to darken the field until at a particular stress (corresponding to one wave-length of phase-difference, or $\epsilon = 360°$) the field is perfectly black again. In an ordinary polariscope, using monochromatic light, we could not then tell, except by inference, that there was any strain at all. Further increase of strain now begins to lighten the field, and the same cycle is repeated indefinitely till the specimen breaks, light and shade succeeding one another in turns as the tension is increased.

This, of course, merely corresponds to the fact that the series of Figs. 13 to 21 repeat time after time as ϵ goes from 0 to 360°, 360 to 720°, 720 to 1080°, and so on.

But with white light, things are different. The most conspicuous result of straining the glass is not to change the intensity of light passing the analyzer, but to change its color. It is this fact that gives polariscopic phenomena their universal appeal and extraordinary beauty. The rainbow is not more brilliant than a piece of strained glass in a polariscope.

Starting with the field dark, the first effect of strain is to produce a pale violet tint, quickly followed by white. Then the color changes to a light yellow, deepening to a yellow-brown with increasing strain. A rather violent transition now takes place to a purplish blue. This sequence of colors now repeats, but the shades are somewhat different, and the final blue is pale. On the third repetition, the colors become fainter, and tend to subside into pinks and greens, and this continues with increasing faintness until at about the seventh repetition, they fade out altogether and the general appearance is white.

It is just as well that the reader should understand how this scheme of colors comes about. They are not "prism" colors, though they are as

brilliant. They are caused by eliminating from the white light one or more of the pure prism colors.

"Prism colors" are colors of a single wave-length. Polariscopic colors are colors of many wave-lengths. They are made by striking one or more bands of color from the spectrum and re-combining the remaining parts. A most instructive and interesting experiment, but one that very few people make, is to mount a spectroscope behind a polariscope and then start to stretch a piece of glass, or better celluloid, in the polariscope. Figure *Q* shows the arrangement. *P* is the polarizer, *A*, the analyzer. *T* is the specimen to be tensioned, the stress of course to be at 45° to the vibration planes of the crossed nicols.

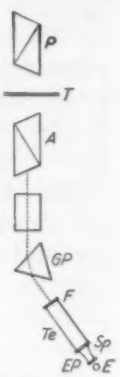


FIG. Q.

GP is a glass prism, *Te*, the telescope of the spectroscope, and *E*, the observer's eye. The spectrum is of course formed at *Sp* by the lens, *F*, and magnified by the eyepiece, *EP*.

A small direct-vision spectroscope is really better than the angular instrument here indicated, because the whole spectrum can conveniently be seen at once.

When we begin, before tension is applied, the field is dark and there is no spectrum.

As soon as we apply tension the spectrum appears complete, but a little brighter at the blue end. This quickly evens up and the spectrum assumes its normal aspect, in which the yellow and yellow-green appear brightest to the eye. A dark shadow now begins to encroach on the violet end. As we watch, it becomes a band of shade that leaves the blue end and travels solemnly down to the red end and over the end and disappears. It is a broad band, cutting a wide swathe from the spectrum.

Before it has completely left the red end of the spectrum a second, much narrower, band appears at the violet end and begins to travel down the spectrum. It has not reached the red end before a third, still narrower band appears at the violet end and we now have two bands in the spectrum at once. They travel jointly red-endwards, separated by a bright piece of spectrum.

Narrower and narrower bands increasingly close together crowd in from the violet end as the tension increases, until the whole spectrum is full of them, and appears to consist of a rapid alternation of color and darkness.

The correlation between the colors of the ordinary polariscope and the banding of the spectrum is very simple.

At a very slight stress the spectrum begins to appear, violet end first, and the tint in the polariscope is violet. When all the spectrum has appeared the polariscope shows the specimen as white. When the first broad black band cuts off the blue end of the spectrum, the specimen in the polariscope looks yellow. As the broad band advances down

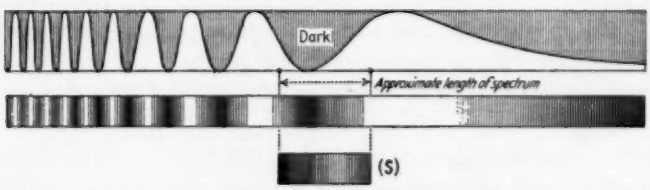
over the blue end and begins to encroach on the green, the specimen's yellow seems to turn reddish or brownish.

The broad band advances further, uncovering the violet and cutting out the green and yellow. The spectrum consists now of blue and red light only, a purplish tint, called the "sensitive tint" or "tint of passage." As the band uncovers more blue and green and cuts out the red, the polariscope color becomes bluer and less purple. The second band now enters from the violet end and we have a spectrum with both ends cut off; the deep violet and deep red are both missing. Enough of the spectrum, however, remains to give a sensation of whiteness in the polariscope.

The passage of the second band repeats the color-sequence of the first, but somewhat modified, because the band is narrower and also because the third band enters before the second is well on its way.

In the later stages, when a number of narrow bands are cut from all parts of the spectrum, the tint in the polariscope is decided by the passage of an extinction band over the yellow-green part of the spectrum. This is the brightest part of the spectrum. When it is missing, the color appears pinkish; when present, it tends to be greenish. Finally the bands get so narrow and numerous that the yellow-green cannot be blotted out as a whole. It may have several bands through it, like all the other colors of the spectrum, but the net result is, to all intents and purposes, that half the light is gone from every part of the spectrum and half is transmitted, and whether the strain in the specimen is a bit more or a bit less or a lot more makes no difference to the polariscope any longer. Bands may come and bands may go, but light of all colors comes through to the extent of 50%.

Those who can make the experiment should do so; it makes a great many things very clear. But in order to get extinctions of such high orders (that is corresponding to 4, 5, 6, or more wave-lengths of phase-difference) it is necessary to use very thick celluloid, $^3/_8$ inch or more. Otherwise the breaking strain of celluloid is reached before the high extinctions arrive. The passage of the first two or three extinction bands is, however, easily observed. With glass, the stresses have to be great and the specimen very thick indeed; the experiment is scarcely practical politics with it.



FIGS. *R* AND *S*.—NOTE: Red end of spectrum at right; blue end at left. The black and white strip that occults the spectrum *S* should be on transparent paper to convey author's idea.

For those who cannot make the experiment I have prepared some diagrams that may serve, rather inadequately, the same purpose.

Figure *R* is a spectrum and Fig. *S* is a diagram of the intensity of light transmitted. This diagram fits over the spectrum and can be moved from left to right over it. To a first approximation it represents the sequence of events very well. When *S* is away to the left the spectrum *R* is in total blackness, *i.e.*, is "extinguished." As the diagram *S* advances, it begins to allow the violet end of the spectrum to appear and soon all the spectrum is showing. Then the first black band cuts in, and then the bands in increasing numbers, much as in the spectroscope itself. The reader is recommended to play with the model a while until its significance is quite clear.

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MECHANICAL PROPERTIES OF SOME ROLLED AND POLISHED GLASS[1]

By E. M. Guyer

ABSTRACT

A comparative study was made of the mechanical properties of several different kinds of rolled and polished glass. Young's modulus of elasticity and the transverse modulus of rupture were measured by the usual cross-bending method. Impact modulus of rupture was measured by means of a special form of pendulum which gave results that were free from the effects of cumulative chipping. Wind resistance was measured with a special form of hydraulic loading machine designed to give uniform pressure of the test plate against the supporting frame. The apparatus is described in detail and the results of the measurements are given in a series of graphs and tables.

Introduction

The work described in this paper was undertaken for the purpose of comparing the mechanical properties of several different kinds of rough-rolled and rolled and polished glass. The mechanical properties determined by the measurements were Young's modulus of elasticity, modulus of rupture, impact modulus of rupture, and wind resistance. Young's modulus was computed in the usual way from observation of the displacement or sag at the center of a narrow rectangular specimen supported near its ends on knife edges, when various known loads were applied. The two rupture moduli were computed from measurements of the forces necessary to produce rupture of glass plates by cross-bending with slowly-applied loads, and by impact with a pendulum, respectively. Wind resistance was measured in terms of the uniform hydrostatic pressure necessary to rupture glass plates supported on four sides by a wooden frame.

Some five hundred specimens were tested which included glass with ribbed, checkered, and other figured surfaces. Both wire glass and ordinary glass of the types mentioned were included in the tests. The apparatus, form of specimen, method of supporting the different specimens, manner of making the measurements, and the results will be described separately for each of the four series of tests.

Measurement of Young's Modulus

The apparatus used for the determination of the elastic modulus consisted of two knife edges (K, K Fig. 1), fastened rigidly to a channel bar base, B, for the support of the specimen, a micrometer telescope for the accurate measurement of the displacement of the center of the specimen, S, and a knife edge, K^1, and weight pan support rod assembly to facilitate loading. The distance between the centers of the knife edges could be adjusted over a short range by a set of lock nuts on a tie rod, T, thus making

[1] Received May 12, 1930.

it possible to keep the same span on successive runs. The specimen was illuminated in such a manner that a sharp image of the edge could be made to coincide with the cross-hair in the eye-piece of the telescope by means of a slow motion screw. Beneath the weight pan, W, was a set of vertical fins, F, which were at all times completely submerged in water. These provided fluid damping to minimize the tendency of the weight-pan assembly to swing or twist when the load was being changed.

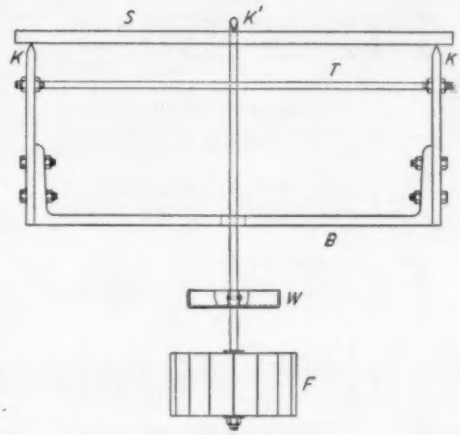

FIG. 1.

In a preliminary test of the apparatus with two samples of the same kind of cold rolled steel, one a rod and the other a flat rectangular plate, it was found that measurements of the elastic modulus could be made with an accuracy of ± 3%. While this limit could not be attained with the glass because of the variation in thickness at different points in the samples which made necessary the adoption of an average value, the elasticity tests could be repeated on samples of glass to within ± 5%.

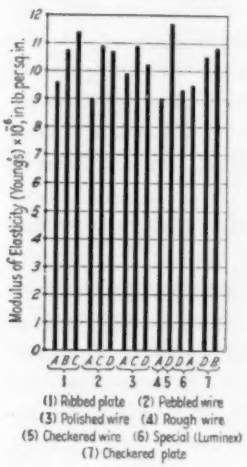

FIG. 2.

The specimens tested ranged in thickness from one-eighth to one-fourth inch, were two inches wide, and had an effective length of eight inches, as determined by the distance between the knife edges. Samples were included of all of the types of glass mentioned in the introduction. All ribbed specimens were cut parallel to the ribs. The average thickness of glass with patterned surfaces was determined by dividing the volume, found by immersion in water, by the product of the length and width.

The results of the Young's modulus measurements are given in Table I and are shown graphically in Fig. 2, where the letters A, B, C, D, refer to glasses of the same type as provided by different manufacturers. The table gives the number of samples tested, the average dimensions of the samples, and the maximum, minimum, and average values of Young's modulus. As might be expected, the variation in elastic modulus is rela-

TABLE I

Description		Dimensions (av. in inches)	Modulus of Elasticity* × 10^{-6} lbs./in.^{2}			Modulus of Rupture** (lbs./in.^{2})			Impact Modulus** × 10^{-6} ft.-lbs./in.^{3}			Wind Resistance† (lbs./ft.^{2})		
			Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.
Ribbed plate	A	0.21 × 2 × 8	10.40	8.60	9.63	11540	7680	9412	211	164.0	178.5	1296	955	1104
	B	0.16 × 2 × 8	11.46	9.98	10.77	11520	7040	9763	191	169.0	174.4	980	432	668
	C	0.21 × 2 × 8	12.50	10.80	11.40	9070	7360	8048	145	132.0	141.0	825	745	798
	A	0.3 × 2 × 8	10.30	8.30	8.99	7980	5820	6986	120.2	53.4	86.9	1295	1085	1200
Pebbled wire	C	0.3 × 2 × 8	12.00	9.70	10.90	7660	3330	5771	94.1	57.1	75.1	905	640	762
	D	0.3 × 2 × 8	11.90	9.80	10.70	8530	5820	7164	92.6	53.7	76.9	865	505	690
	A	0.3 × 2 × 8	10.70	8.30	9.90	11380	6690	9219	142.6	69.2	91.8	1150	890	1031
Polished wire	C	0.3 × 2 × 8	11.20	10.60	10.90	7980	5340	6286	71.7	63.7	67.8	1075	875	1011
	D	0.3 × 2 × 8	11.00	9.90	10.20	11330	6190	8591	114.0	58.4	83.2	1300	430	890
	A	0.3 × 2 × 8	10.30	7.20	9.00	8890	4180	6946	133	88.6	104.8	810	760	763
Rough wire	D	0.3 × 2 × 8	13.59	9.81	11.70	9060	6670	8199	155.9	88.2	106.7	865	610	710
Checkered wire	A	0.20 × 2 × 8	10.10	8.90	9.45	11568	6320	8577	175	136.0	145.0	775	670	725
Luminex	A	0.22 × 2 × 8	9.40	9.20	9.30	10860	8260	9919	193	130.0	170.5	915	710	765
Checkered plate	B	0.2 × 2 × 8	11.43	9.96	10.75	10740	7540	9237	168	87.1	137.4	935	575	672
"	D	0.2 × 2 × 8	11.30	9.76	10.50	10550	7883	8888	169	103.0	147.0			

* Number of tests, 20
** Number of tests, 5
† Number of tests, 6

tively small as compared to the other mechanical properties which involve actual rupture of the material in their determination. No difference, within the limits of experimental error, was found between measurements made with the patterned surface up and those made with the smooth side up, provided the elastic limit was not exceeded.

Modulus of Rupture

The modulus of rupture apparatus, shown in Fig. 3, was the same as that used to determine Young's modulus, with the addition of a mechanism for the continuous loading of the specimen up to the point of rupture. This was accomplished by the use of a shot hopper, H, with a hinged trough, T, of variable slope, to regulate the rate of flow of the shot. The former weight pan was replaced by a hollow shot receiver, S, made in the shape of a cone to insure centering the load beneath the point of support. One of the knife edges, K, which supported the specimen was rendered freely floating by a special pivot mounting. As the center, or weight support, knife edge was already free,

the system was thus self-adjusting with the knife edges at all times accurately parallel.

The specimens were from the same group used for Young's modulus determinations. They were placed on the knife edges with the figured surface up so that the smooth lower side was the portion subjected to tensile stress while the weaker upper surface was compressed.

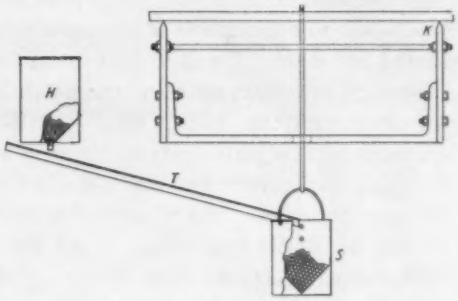

FIG. 3.

The results of the modulus of rupture tests are given in Table I and shown graphically in Fig. 4. The greater variation of these values as compared to the elastic properties is to be accounted for by the fact that elasticity is primarily a volume characteristic but slightly affected by surface or edge effects. Properties involving rupture of the material, on the contrary, are determined to a much greater extent by small cracks and abrasions in the surface which grow and spread rapidly once the elastic limit of the material is exceeded.

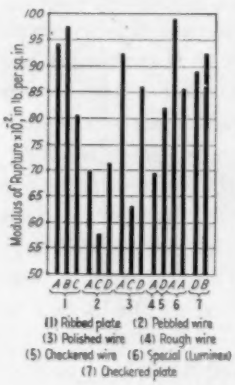

FIG. 4.

Impact Modulus of Rupture

This property was computed by a formula, of more or less arbitrary derivation, given by Williams.[2] The apparatus for carrying out the measurements consisted of a 24-inch pendulum, *P* (Fig. 5), with a cylindrical tup $1^3/_8$ inches in diameter by $^1/_2$ inch thick, which had rounded edges so as to present an approximately spherical section at the surface of impact. The effective weight of the pendulum was 12 oz. It was released from a definite height by an adjustable electromagnet, *M*, and allowed to swing beyond its rest position and to rise a measured distance on the far side. The apparatus was calibrated directly in foot-pounds of energy and

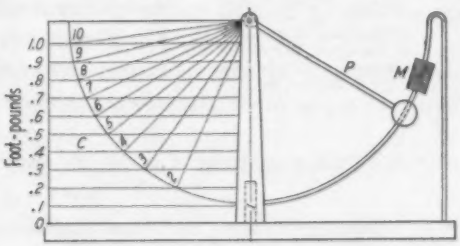

FIG 5.

[2] A. E. Williams, *Jour. Amer. Ceram. Soc.*, **6**, 980–88 (1923).

could be read by means of a vertical chart, *C*, almost in contact with the swinging pendulum. On this chart was a trace of the actual path of the pendulum together with numbered radii which spread out from the point of suspension of the pendulum. A series of horizontal lines drawn through the point of intersection of the numbered radial lines with the arc completed the scale. On each horizontal line was the number of foot-pounds of energy necessary to raise the pendulum to that particular line. Thus by subtracting the "energy level" to which the pendulum rose after passing through a glass plate from the level it rose to with no glass plate in the machine, a measurement was obtained of the energy used up in breaking through the glass. Since pivot friction was effective on the free swing, as well as on the test swing, it did not enter the results but disappeared with the subtraction. The special advantages which it is believed have been obtained with this instrument are (1) freedom from cumulative chipping and cracking prior to the actual break, a fault which is inherent in all schemes for pendulum tests that involve repeated impacts, and (2) simplicity in taking readings by virtue of direct calibration.

This system was not found practical, however, in the case of heavy wire glasses because of the relatively large energy necessary to tear through the wire meshes. Consequently, for these glasses the pendulum was dropped from successive heights until the impact resulted in rupture.

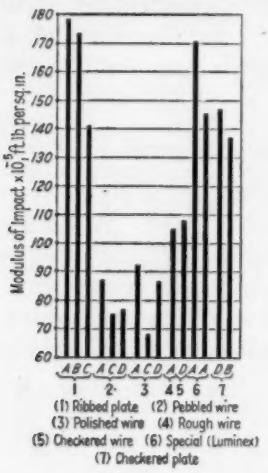

FIG. 6.

The specimens were of the same dimensions and description as those used in the previous tests. They were set on edge and held firmly against supports near their ends in such a way that the impact was delivered at the center of an 8-inch span.

The results of the impact tests are given in Table I and appear in the graph of Fig. 6. It is significant that the wire glasses tested by successive impacts show much lower values than the glasses tested by single impact. It is, of course, permissible to compare the wire glasses among themselves only but not directly with the various plain glasses which were tested by what is thought to be the superior method.

Wind Resistance

The apparatus for the so-called wind-resistance tests consisted of a slotted frame, *F*, Fig. 7, of hard wood into which 14- by 20-inch glass plates, *G*, of different thicknesses could be slipped by removing a special

demountable end bar. The end bar could then be bolted tightly into place effectively closing the slot, but without in any way bringing pressure to bear on the test plate which floated freely on a rubber diaphragm, *D*. Water could then be admitted slowly to a series of thin-walled rubber bladders, *B*, confined in the lower part of the mechanism, which expanded and in so doing pressed the rubber diaphragm up against the glass plate under test. As the uniform upward motion continued, the glass plate was finally prevented from rising farther by contact between its periphery and the hard wood frame which overlapped the glass by $^1/_2$ inch. This method of framing the test piece is believed to have eliminated the production of undesirable stresses in the glass due to uneven frame pressure. The pressure was allowed to rise until rupture occurred, the maximum pressure being read on a mercury manometer, *M*.

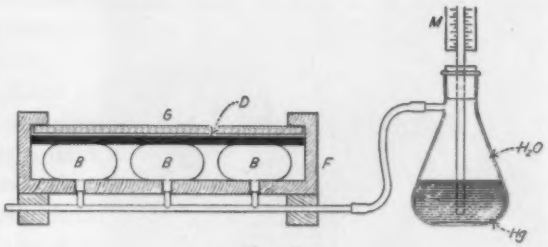

FIG. 7.

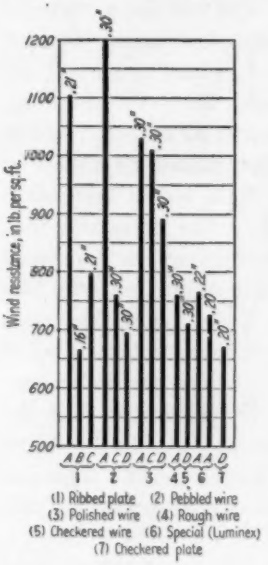

FIG. 8.

The average pressures, in pounds per square foot, at which the different types of glass were broken are given in Table I and are shown graphically in Fig. 8. The very high pressure necessary to rupture pebbled wire, *A*, in comparison to *B* and *C*, is to be accounted for by the fact that the wire-mesh pressed into *A* is located very nearly along the neutral axis of the specimen (*i.e.*, half way between the surfaces) while in both *B* and *C*, the wire is located near the pebbled surface in the zone of tension where the glass is weakest.

Because of the occurrence of unknown constants, characteristic of the material, in formulas for the strength of plates supported at the edges, no effort has been made to reduce the wind-resistance data to a modulus.

Figure 9 shows a typical break obtained with the hydraulic frame. The center line is indicated in the picture which would otherwise lead to incorrect conclusions as to the position of the initial break. Because of the steep angle at which the camera was inclined to bring out the fracture lines in the glass, the center appears to be displaced toward the farther

end but the reference line, drawn between the middle bolts in the opposite sides of the frame, shows the center of fracture to be very nearly in the center of the plate. The whole pattern of the fracture shows distinctly that the glass broke first near the center at the point of maximum stress with a subsequent radial growth of cracks toward the sides. There is no evidence whatever of a frame break which would result from nonuniform stresses at the supporting edges.

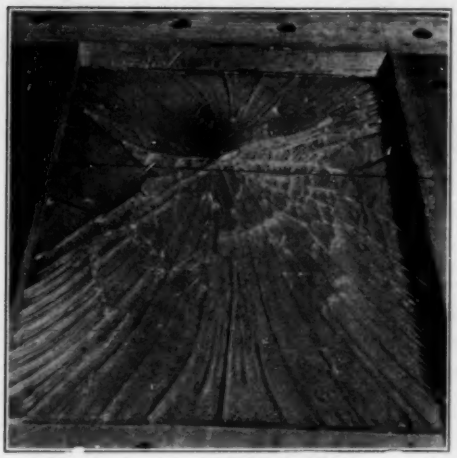

FIG. 9.

Discussion

The results are considered to be as regular and as accurate as can be expected for a material of the complex nature of glass, tested without recourse to special treatment of edges and surfaces. All special preparations of the surface and edges would, however, place the tests on a purely laboratory basis for unless the material is tested in the physical condition in which it is used the results cannot be taken as indicative of its probable behaviors in practice. It is to be concluded from the present results and from data recorded in the literature that the behavior of glass under given conditions of stress cannot be expressed in terms of a definite set of parameters characteristic of the material like the constants of the simpler structural materials. It is found that such parameters determined by measurements on one specimen, under one set of conditions, apply rigorously to that specimen alone for the particular conditions under which they were obtained. This view indicates that the application of such measurements is limited almost entirely to direct comparison, the value of the test depending very largely on the degree of similarity in dimensions and other physical conditions possessed by the specimens.

Definite correlation seems to exist between the different tests, at least to the extent that those glasses which had the highest modulus of rupture had also the lowest Young's modulus, as would be expected. This statement holds only for variations in modulus of rupture greater than 5% as will be seen by comparison of the graphs. Variations below this limit must be taken as too small to be considered.

The wind-resistance measurements of Fig. 4 cannot be compared with the computed moduli of the other figures as they are direct plots of the data

and are not influenced by any particular method of computation. They apply, therefore, only to the thicknesses indicated on the graph.

Of the three rupture tests the wind-resistance measurements are believed to be the most promising for future investigation as they involve specimens approaching most nearly to practical conditions both in dimensions and manner of mounting. Edge effects are practically eliminated by the method of framing here described instead of playing an exaggerated part as they do in all tests on narrow rectangles. This was shown by certain tests in which it was found that a specimen with a corner missing broke at normal pressure. While surface conditions, particularly in the vicinity of the center of the plate, must exercise a relatively great influence on the apparent breaking point, it is felt that these factors enter the results of the hydraulic frame tests to an extent approaching, more nearly, that found in ordinary working conditions.

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DIMENSIONAL CHANGES CAUSED IN GLASS BY HEATING CYCLES[1]

By A. Q. Tool, D. B. Lloyd, and G. E. Merritt

ABSTRACT

In obtaining expansivity curves for a medium flint glass, samples of the glass were tested which had previously received one or another of several different heat treatments, and in these tests heating cycles were employed which made it possible to determine that the magnitude of the so-called "permanent" changes in length are caused either by the annealing or the "disannealing" which may result from the heat treatment imposed on the glass by the heating cycle employed. Annealing decreases the length and specific volume, while disannealing increases them. It is shown that these effects are related to certain ice-point shifts observed in thermometers, and to other effects sometimes observed in various types of glassware.

I. Introduction

In common with a great many other materials glass will generally show, as a result of cyclic heat treatments extending over considerable temperature ranges, more or less permanent changes in its specific volume as well as in its form.

Volume Change at Atmospheric Temperatures

It is not always necessary that the treatments reach temperatures in the so-called annealing and softening ranges to cause such effects, since detectable changes in the specific volume (when determined at any one temperature) are at times produced by treatments which do not reach temperatures much above those of the atmosphere. The changes resulting at such low temperatures in well-annealed glass are, however, small and of little consequence when compared with those which are obtainable only at higher temperatures or which are the result of a failure of the glass to have reached the proper state of physico-chemical equilibrium when it was annealed. These dimensional changes produced by subjecting glasses to heating cycles approaching the annealing range are the subject of this investigation.

Ice-Point Shifts Due to Glass Imperfections

Certain of the well known fluctuations and displacements common in the ice-points of mercury in glass thermometers undoubtedly result from these changes in specific volume.[2] To introduce the subject of this

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[1] Publication approved by the Director of the Bureau of Standards, U. S. Department of Commerce. This paper is also being published in the Bureau of Standards, *Journal of Research*.

Presented at the Annual Meeting, American Ceramic Society, Chicago, Illinois, February, 1929 (Glass Division). Received July 1, 1930.

[2] Young, *Nature*, **41**, 488 (1890). In this paper, Young, besides ascribing the rise of the ice-point to a volume change caused by the molecules assuming a position of greater stability, also refers to several interesting notes and articles on this subject by himself and others.

paper more definitely, a discussion of these ice-point shifts and their possible causes will, therefore, be included here.

Of the ice-point shifts generally observed, part of the smaller ones (especially those occurring without heating above relatively low temperatures) may be traceable to changes in the shape of the bulb which result from variable strains. Strains introduced during the formation of the bulb and which remain effective because the annealing is insufficient may be of this character since they usually change slowly. Semipermanent or variable strains may also develop in an annealed bulb during the actual use of a thermometer in temperature ranges never reaching the annealing range if, for any reason, the expansivity and the possible specific volume change are not uniform over all parts of the glass or glasses used in making the instrument. These non-uniformities may arise from striae, the use of two different glasses, differences in the amount of working the glass receives when fused, or from temperature gradients during the fusions and annealing. Ice-point shifts from such causes should, however, generally be small and it would seem that they might with almost equal probability be either positive or negative. Furthermore, it would seem that while they cannot be eliminated entirely, a proper choice of glasses and suitable methods of producing both the glass and thermometers should make their significance negligible.

(1) Ice-Point Shift Due to Uniform Change in Specific Volume at Low Temperatures

Another type of ice-point shift which may occur and which results entirely from uniform changes in specific volume may be divided into two classes. As in the cases of those ice-point shifts due to strains, the magnitude of those in the first class to be considered should be small and after being produced should usually decrease more and more slowly with time while the thermometer is held at a practically constant temperature near zero. On the basis of their assumed cause these shifts when observed at the minimum temperature of a cycle will, however, always have the nature of a depression and they will also develop, although their magnitude will usually decrease almost linearly with the extent of the range, after heating and cooling cycles which are within and consequently smaller than the usual 0 to 100°C testing range. On extending the range to higher temperatures the observed depression should first increase and then decrease.

General experience with glass, and other materials as well, suggests that these depressions result after heating and cooling cycles because the specific volume of even well annealed glass, after allowing for the change due to the normal expansivity, changes in a cycle which lags behind the causative temperature cycle impressed on the glass. That is, after a thermometer is heated very rapidly from 0 to 100°C, for example, and after its temperature becomes uniform, the expansion of the glass due to its normal expan-

sivity is completed; the bulb, however, will still continue to expand slightly at a decreasing rate. This additional expansion, which continues at a constant temperature and which appears to be of sufficient magnitude and to proceed slowly enough even at 100°C for observation in thermometers made from glasses that are subject to relatively large depressions in this range, corresponds to a slow increase in the specific volume of the glass.

On cooling to zero to complete the cycle, this increase in volume will persist for a relatively long time since in general all such readjustments proceed more slowly at lower temperatures.

Work by a number of investigators was required in the development of thermometer glasses which were not unduly subject to the depressions which may be ascribed to readjustments of this kind and thermometers now made from the best of these glasses seldom show, for cycles between 0°C and 100°C, depressions of more than 0.1°C.

(2) Ice-Point Shift Due to Specific Volume Change at Higher Temperatures

When, however, the temperature cycles are not confined to these relatively restricted ranges, such as 0 to 100°C, but are increased until temperatures near or within the annealing range are approached, the observed ice-point shifts become in general much larger. Such shifts are of the second class which may be ascribed to specific volume changes in the glass, and contrasted to the first class they may, depending on circumstances, consist of either depressions or elevations with the latter being far more common in practical thermometry.

These differences between the two classes arise from the fact that the noticeable readjustments possible in different temperature ranges are different. Thus, at 100°C for example, the only noticeably active readjustments in a glass previously held at 0° are generally all comparable to disannealing processes although the state of the glass at 100° is not one of equilibrium for that temperature but for some much higher temperature. That is, when a thermometer, for example, is annealed and cooled, all major readjustments which might produce equilibrium at 100°C cease to operate at any appreciable rate long before this temperature is reached. Certain minor readjustments, however, continue through this point and until the glass is nearer to, or reaches, zero.

On reheating, the minor processes are reversed and disannealing results throughout a considerable range, G. (See footnote 3.) This effect alone is noticeable until some temperature range, G_1, well above 100°C is reached where the major processes again operate at a noticeable rate and the annealing readjustment with its usual decrease in specific volume is resumed.

If the heating is continued until a range, G_2, is reached, which is above the temperature corresponding to the equilibrium condition produced in the glass by the previous annealing treatment, the majority of the annealing processes will be reversed and a disannealing somewhat similar to that at

100°C with its usual increase in specific volume will again be the predominant effect.

If, instead of continuing the heating, the thermometer had been held for some time at any temperature below G_1 and then cooled rapidly, an ice-point depression would have resulted. Treating and cooling in the same manner from any point in G_1 would have produced an elevation, the magnitude of which would depend on various factors. From G_2 such treatments would again produce depressions.[3]

All of these effects may be modified by, but they are not the result of, strains; and it is in fact only those ice-point displacements that are not caused by strains and which may be obtained only by heating to temperatures in and above G_1 that correspond to the experimental results on changing the specific volume which are shown in this paper.

In regard to the magnitude of these particular ice-point displacements, it is well known that under some conditions shifts amounting to 30°C or more are possible even when the heating cycles are extended to temperatures only moderately high.

Since density changes of corresponding magnitudes may be obtained by varying the annealing schedules of most glasses it appears that these particular shifts are caused mainly by changes in the specific volumes of thermometer glasses.

The fact that these large ice-point shifts are more often elevations than depressions is merely a consequence of the ordinary practices followed in the manufacture and use of thermometers. That is, either the scales and consequently the probable heating cycles to which the thermometers will be subjected when in use, extend to temperatures which are near or within the annealing ranges of the glasses without actually reaching the effective temperatures[4] of the annealing treatments previously given to the thermometers; or, these annealing treatments were entirely inadequate since they failed to establish those physico-chemical conditions which are reasonably stable at all temperatures below the annealing range.

Inadequate annealing is, of course, indefensible but the practice of

[3] In Fig. 1 the region to the right of PQ contains the ranges G_2. Ranges G_1 are to the left of PQ and above some boundary corresponding to S but which will usually include more of the lower temperatures. Ranges G are to the left of PQ and below this rather indefinite boundary corresponding to S.

[4] The effective temperature of an annealing treatment may be defined as that annealing temperature at which practically the same effect produced on the physico-chemical condition by the actual schedule employed might have been obtained through an annealing period at that temperature adequate to produce physico-chemical equilibrium and by a cooling rate such that no further annealing occurred during the cooling period. The resultant effective temperatures of ordinary annealing treatments may be either lower or higher than the actual temperature employed. It is usually lower if the temperature used is high in the annealing range and the cooling rate is low; while it is generally higher if the temperature employed is low and the annealing period is short.

somewhat over-extending the scales may in some very exceptional cases be justified. This practice should, however, be avoided if possible and it should never be followed without providing an adequate annealing which presumably should be given just before filling and graduating the thermometer and at temperatures as near the top of the proposed scale as possible. Normally it would appear that an adequate annealing treatment for a thermometer is one which will produce a physico-chemical condition corresponding closely to one of equilibrium for a temperature not too far above the lower limit of the practical annealing range. This temperature corresponding to the equilibrium condition is defined[4] as the effective annealing temperature of an annealing treatment and when a thermometer is heated to points above it an ice-point depression will usually be observed as previously stated.

(3) Lower Limit of Annealing Range Is Lower Than Temperature Used in Annealing

The fact that a thermometer cannot be expected to give a satisfactory performance if it is heated to temperatures which exceed the lower limit of the annealing range is well known, but it does not appear to be so generally appreciated that this limit is considerably lower than those temperatures which may be employed in giving a glass a reasonably thorough and for most purposes a sufficient annealing in a reasonable time. The best means of determining for a given glass a safe upper limit for the scale is, of course, to extend the heating cycles imposed on a comparatively well-annealed test thermometer of the glass gradually to higher and higher temperatures until the point is finally reached where a treatment of several hours at the maximum temperatures of the cycles begins to produce ice-point displacements which just approach the specified tolerances for such shifts.[5] That this apparently self-evident precaution is often neglected is shown by the fact that many thermometers are graduated as far as 50°C or 100°C into that more or less indefinite region termed the annealing range. Such thermometers on being used to register these high temperatures can scarcely be expected to meet successfully any reasonable specifications.

(4) Inter-relation of Specific Volume to Other Properties of Glass

That unwarranted requirements such as this use of thermometers at too high temperatures are so often imposed on a glass when they could in most cases be obviated merely by making a correct choice from the glasses available, can

[5] A limit so determined will usually be well below that which is determined by noting the temperature at which the internal pressure from the gas over the mercury column causes the bulb to distend. As a matter of fact, in the G_1 range the two effects involved are of opposite sign. With a well-annealed thermometer, the G_1 shifts may all be smaller than a reasonable tolerance. In such a case, however, it is likely that the G_2 shifts will become excessive long before the depressions due to pressure become marked.

only be explained by assuming that there exists in many quarters an insufficient knowledge concerning certain important characteristics of this ma-

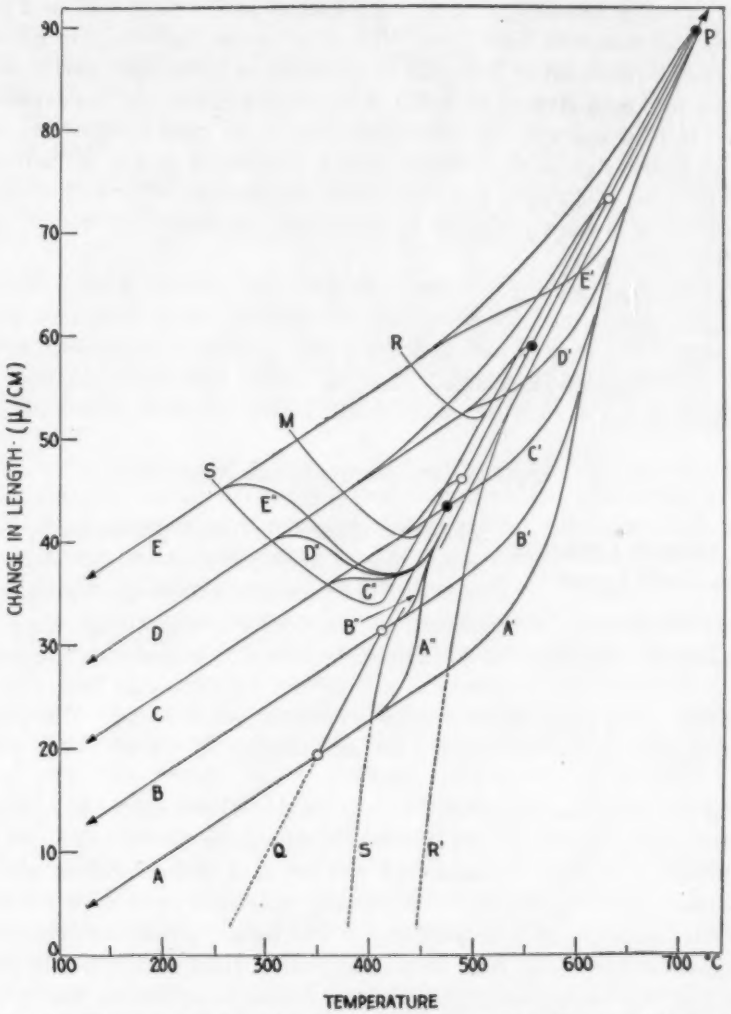

FIG. 1.—Diagram showing the effects of heating and cooling conditions on properties of glass. (See p. 653 for explanation of this figure.)

terial. To aid in presenting a clear conception of these characteristics it was planned some years ago to undertake, in connection with the density determinations in progress, an investigation which would involve a series of expansivity measurements on several samples of a glass each of which was

to have received previously a heat treatment considerably different from that of the others.

At that time a tentative diagram similar to Fig. 1 was prepared as an aid in choosing desirable treating temperatures and in predicting and interpreting the results of such tests. To some extent this diagram followed the presentation used by Marchis[6] in his thesis on permanent modifications of glass but with respect to detail it was based chiefly on the experience gained from a study of the particular glass to be used in the tests, on a general knowledge of the changes which are caused in the properties of glass by heat treatment, and on certain generalizations arrived at after a consideration of the expansivity measurements obtained by Peters, Cragoe, Merritt, and others.[7]

This diagram (see Fig. 1) with some modification is included in the present article mainly because such diagrams have at times been very useful. Although it has certain patent defects, they cannot be properly remedied until more data are available. It is, however, sufficiently accurate and elaborate to aid in the discussion of the results presented in this paper.

II. Experimental Methods and Apparatus

(1) General Character of the Glass Tested

The glass chosen for these preliminary experiments was a medium flint, B. S. Melt 494, that had been used in previous investigations[8] on the effect of heat treatment on the density, refractivity, etc. This choice was made because it was desired to compare the dimensional changes caused by the heating cycles imposed on the glass samples during the expansivity tests with those results previously secured from the density changes observed in the same glass and already described in the papers cited.

The practical annealing range of this glass lies between the approximate limits 370°C and 470°C At the lower temperature the time required for a practically complete relaxation of stresses and the establishment of a physico-chemical equilibrium considerably exceeds a month; while at the upper temperature it is of the order of one hour. From the previous investigations it had also been found that the original cooling of the pot of glass had been such that the effective annealing temperature was between 400°C and 410°C. It had also been found that small pieces could be

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[6] L. Marchis, Les Modifications Permanentes du Verre et le Déplacement du Zéro des Thermomètres, Paris (1898).

[7] Peters and Cragoe, Bur. Stand., *Sci. Paper*, No. 393 (1920); Merritt, *ibid.*, No. 485 (1924); Peters, *ibid.*, No. 521 (1926).

[8] Tool and Hill, *Trans. Soc. Glass Tech.*, **9**, 185 (1925); Tool, Tilton, and Hill, *J. O. S. A. & R. S. I.*, **12**, 490 (1926); Tool and Eichlin, Bur. Stand., *Jour. Research.*

cooled in air at atmospheric temperatures from all temperatures below 420°C without introducing permanent stresses materially exceeding the tolerances required for well-annealed glass. Furthermore, below 400°C a much slower cooling did not, it appeared, give the glass the opportunity to follow the course of equilibrium conditions (indicated in Fig. 1 by the line *PQ*) but compelled it, rather, to follow the courses of normal or true expansivity conditions represented by the lines designated by *A*, *B*, etc. From temperatures above 450°C, however, chilling in atmospheric air was not drastic enough to prevent all drift along *PQ* and it was necessary to resort to quenching in water whenever, for example, it was desired to make the glass follow closely the line *C*. Even this drastic treatment fails to halt the drift along *PQ* if the quenching is from temperatures in the range above the approximate limit 500°C. This need of increasing the severity of the chilling whenever the quenching temperature is raised and whenever it is at the same time proposed to prevent a drift along *PQ* reflects the rapidity with which the rate of approaching a physico-chemical equilibrium increases as the temperature of the glass rises through the annealing range.

The fixing of the more or less definite temperature limits given above for the different cooling treatments has, of course, no justification except that it aids in presenting the results of experience. In other words, anything but an arbitrary setting of such limits is precluded just as it is in the case of fixing limits for the usual or practical annealing range.

(2) Heat Treatment of Samples

Since the intention was to measure the expansivities and permanent dimensional changes on several samples, each of which should be in a condition which corresponds to a different position on the line *PQ*, nine lots of small glass pieces were prepared, each lot being large enough to make several test specimens. Eight treating temperatures (360, 370, 390, 400, 420, 440, 470, and 620°C) were chosen and the heating periods at these temperatures varied from a few minutes at 620° to more than one and one-half months at 360°. It had previously been found that the required treating period could be approximately halved for each 8 or 10°C increase in the treating temperature. The lot treated at 620° was quenched in water; the remainder were air-chilled. Despite the smallness of the pieces, the lots treated at 620°C and 470°C drifted during the first part of the cooling toward physico-chemical equilibria corresponding to temperatures well below their respective treating temperatures. With the higher temperature the magnitude of the drift probably approached 100°C, but with the lower (470°C) it was much less. For the rest of the samples it is believed the drifts were inappreciable. It was found, however, that the treatment given at 360°C was too short to reduce the glass completely to equilibrium at that temperature.

(3) Preparation of Test Specimens As the present investigation was more or less preliminary, variations in the size and shape of the test specimens were tried. The usual shape, however, was that of a pyramid whose base was so cut that it rested on three well separated feet, thus supplying the stability required of a separator in a sensitive Fizeau interferometer. The surfaces of the feet and the apex were smoothly rounded so that there would not be, at the higher temperatures, an undue deformation at the points of contact between the specimens and the two fused quartz plates used in the interferometer.[9] In each test a set of three such pyramids all having practically the same height were, of course, needed to serve as separators in supporting the upper plate at the desired distance above the lower one. The final height adjustments required to give suitable interference bands for expansivity measurements by this method have been described in sufficient detail by C. G. Peters and his associates in the articles cited. The height of the pyramids used at different times ranged between one and five millimeters, and was in every case carefully measured on a special disk anvil micrometer. In general, the pyramids with broad bases and relatively short altitudes gave the most consistent results; presumably because of two reasons: their greater stability and the closer adherence of their temperature to that of the bottom interferometer plate which, as described later, was used to determine the temperatures.

(4) The Furnace The interferometer system formed by the quartz plates and these pyramidal test specimens was heated and cooled during the expansivity measurements in a tubular electric furnace similar to that described by Peters and Cragoe.[9] A helix of aluminum tubing buried in the thermal insulation and surrounding the heating coil constituted, however, one modification. Through this tube a flow of some gas or liquid could be used to maintain the desired rate of cooling. Another modification consisted in replacing the customary porcelain cup containing the interferometer by a thick-walled one of aluminum. This cup served better to equalize the temperatures of the interferometer system. The introduction of these aluminum parts restricts the use of the furnace to temperatures below 600°C since the melting point of aluminum should not be too closely approached. In other respects these aluminum parts proved satisfactory, and for higher temperatures other metals are available. The heating and cooling rates employed in the tests recorded here approximated 3° per minute.

(5) The Temperature Measurements Two methods of determining the temperature were used. In the first, a thermocouple with its hot junction in contact with the base of the

[9] Peters and Cragoe, Bur. Stand., *Sci. Paper*, No. 393 (1920); Merritt, *ibid.*, No. 485 (1924); Peters, *ibid.*, No. 521 (1926); Merritt and Peters, *Jour. Amer. Ceram. Soc.*, 9, 327 (1926).

aluminum cup containing the interferometer was employed in the usual manner. This served mainly as a control of the heating rates but it also gave a check on the second method particularly when the temperature was being held constant. The second method consisted of using the lower interferometer plate[10] as a "refraction thermometer" and was depended upon to give a more accurate determination of the actual temperatures of the test specimens, since they were in direct contact with this plate. In reference to this plate it will suffice to say that its thickness and the relative inclination of its surfaces were such that it gave a satisfactory set of straight interference fringes which shifted approximately one fringe for each 5 or 6° change in temperature. As the movement of these fringes was at all times very regular throughout their length and since a shift can be estimated to a tenth of a fringe with considerable accuracy, the precision of the temperature determinations was of the order of one-half degree. If desired, the top plate may be so designed that a part of it may also be used as a refraction thermometer. In this way the axial temperature gradients existing in the space containing the test specimens may be determined; but the number of fringe systems requiring practically simultaneous attention is then such that a chronograph or other suitable system would be desirable for recording the passage of the fringes.

(6) The Measurement of Fringe Displacements

The shifts of the fringe system of the bottom plate and of that of the air wedge determined by the lengths of the test specimens between the two plates were determined by means of the usual equipment which is described in the articles cited. With the exception of a few cases where the test specimens were so tall that the air fringes moved very rapidly past the reference point on the top plate and in such numbers that to have recorded all of them would have been too laborious, the time of practically every such passing of a whole fringe was recorded. As each air fringe count was recorded, the number and fractional part of the refraction thermometer fringes which had passed the reference point up to that time were also recorded. When the test specimens were relatively small or the temperature was being held stationary it was occasionally considered advisable to increase the number of observations on the air fringes beyond that of the whole bands. The labor required in recording the increased number of observations is compensated for by the advantage gained when it is found necessary to correct any count which proves to have been erroneous because of the accidental omission of a whole band and also by the greater certainty regarding the trend of the curves in graphical representations of the data. Furthermore, any instability on the part of the interferometer system is also more readily detected by using a larger number of points.

[10] This plate was designed and calibrated for this purpose by Mr. Merritt who plans in the near future to describe the method more fully.

(7) The Heating Cycle The upper limit of the heating cycles was chosen with the special purpose of keeping the glass at temperatures where it would not deform appreciably under the weight of the top plate. At the same time it was necessary for the chief purpose in view that this limit should be in the range where a physico-chemical equilibrium would practically be reached in a few hours if the time for procuring the data on a complete cycle was not to be too long. Preliminary tests showed this limit to be both safe and convenient when between 440°C and 445°C, since at this temperature a large portion of the dimensional changes due to physico-chemical processes were completed within two hours, although appreciable deformations were not detected after the heating had been continued for several hours. The heating cycle, therefore, consisted of heating the interferometer system, formed by the two plates and three pyramidal spacers all contained in the aluminum cup, at approximately 3°C per minute from room temperature to 443°C, holding it there until the expansion due to physico-chemical changes appeared to be complete, and then of cooling it to the starting temperature at approximately the same rate. At the end of such a run the glass spacers were in general either longer or shorter,[11] depending on the initial condition of the glass. If the effective treating temperature corresponding to this initial condition was below 443°C, the length of the spacers was increased by the cycle; if it was above, the length was decreased. The magnitude of these changes is controlled chiefly by this difference between the initial effective treating temperature and the holding temperature of the cycle, but it will naturally be reduced if the holding period is insufficient and will be somewhat affected by the changes which progress during the cooling. To insure against insufficient holding periods a second, and sometimes a third, run was made.

III. Experimental Results

All details, such as the formula required, the corrections which must be applied because of the air density changes, and so on, which are involved in converting the fringe displacements caused by the changing altitudes of the pyramidal spacers into changes in length per centimeter have been sufficiently described in the articles mentioned above. Figures 2 to 7 represent graphically the changes in length with temperature which were obtained for the differently treated samples. To make sure that the curves shown represented with sufficient fidelity the expansions and contractions which should result from the previous treatments of the samples, two or more sets of pyramids from each of the nine lots were tested.

Not infrequently there occurred during these runs (usually after the first

[11] Schönborn, *Sprechsaal*, **61**, 99 (1928). This author has published considerable data on the shortening of chilled glass rods.

heating) certain small abrupt fringe displacements which appeared to be in no wise related to the temperature of the glass, and although their combined magnitudes seldom materially affected the general result of any run their

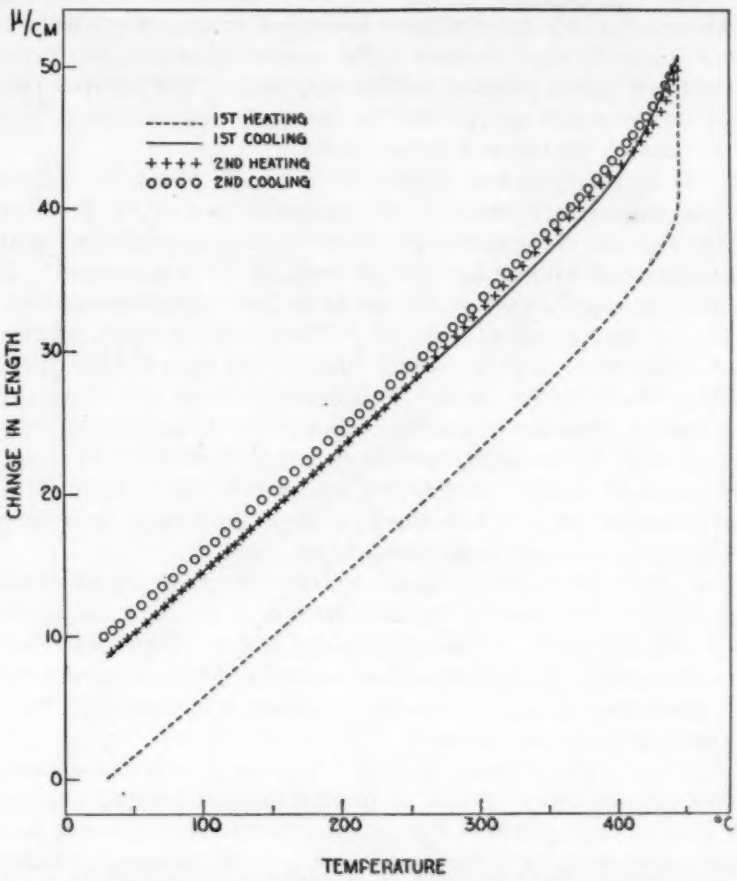

FIG. 2.—Expansion curves obtained on a sample of glass previously treated at 360°C for 47 days and cooled in air. 1st cycle: Heating curve indicated by broken line; cooling curve by continuous line. Held at maximum temperature approximately 1 hour. 2nd cycle: Heating curve indicated by crosses; cooling curve by circles. Held at maximum temperature approximately 15 minutes. The unit μ (one micron) used in the ordinates is 10^{-4} cm.

occurrence did make repetitions of the tests even more desirable. Such repetitions revealed that these abrupt displacements were entirely accidental and that in most cases they could be either compensated for by taking into account the two or more sets of observations or entirely neglected in deciding upon the most probable trend of the expansion curves.

Since the curves in the figures lie so close together, it was found impossible to show the points corresponding to each individual observation and consequently only the smooth trend is given. This procedure does not make these displacements evident but they were none the less definite.

With regard to the cause of these accidental effects, they seemed to be induced chiefly by the difference in the expansions of the glass pyramids and the fused quartz plates in contact with them. The effect of this difference was probably exaggerated by the slight temperature differences existing between the top and bottom plates.

As long as the specimens slipped freely on the plates, the differential expansion caused little trouble; consequently, most of the first heating after the exposure of the interferometer to ordinary atmospheric conditions was accomplished without any marked irregularities in movement. These were likely to appear, however, as soon as the heating had cleared away the possible lubricating films of gases, etc. They were, therefore, presumably caused or accentuated by a gradual tilting of the spacers when these did not slip properly on the plates. This action changed for a time the apparent rate of expansion which was in most cases ultimately compensated for by a return of the interferometer system to stability. At times this return would be abrupt; at others it was gradual, often causing the apparent expansion curve to show changes in slope which might be erroneously interpreted as indicating some change in the glass.

These erratic effects are apt to be very troublesome in obtaining cooling curves whenever the heating has been pushed to temperatures where the spacers cohere[12] slightly to the fused quartz plates. This occurs to some degree with smooth plates but much more often and to a greater extent with plates which have become somewhat roughened and thus allow the glass to fit into and grip their surfaces.

The curves in Fig. 2 show essentially how the glass of the sample previously treated at 360°C follows, on the first heating, a normal expansivity curve (similar to *A* and *B* in Fig. 1) until the line corresponding to equilibrium conditions (*PQ* in Fig. 1) is crossed. This crossing probably occurred shortly after reaching 370°C, because it was found that the treatment at 360°C had not been long enough to produce more than the effect of a completely effective treatment at 370°C. This would mean, in view of the rate of heating employed, that shortly after reaching 370°C, possibly near 400°C, the apparent expansivity should increase somewhat because of a drift toward equilibrium. This drift, which in this case is not very marked until 420°C is reached, signifies the introduction of a "permanent" increase in volume. Although the temperature was maintained practically constant at the holding temperature, 443°C, the increase in length during the holding period was almost a sixth of the total change which took place

[12] Klemm and Berger, *Glastech. Ber.*, **5**, 405 (1927).

due to normal thermal expansion between room temperature and this holding temperature.

Considering the low internal mobility of the glass and its resultant slow change toward equilibrium at this and lower temperatures, the rate of cooling, 3°C per minute, is rapid and, consequently, the curve represent-

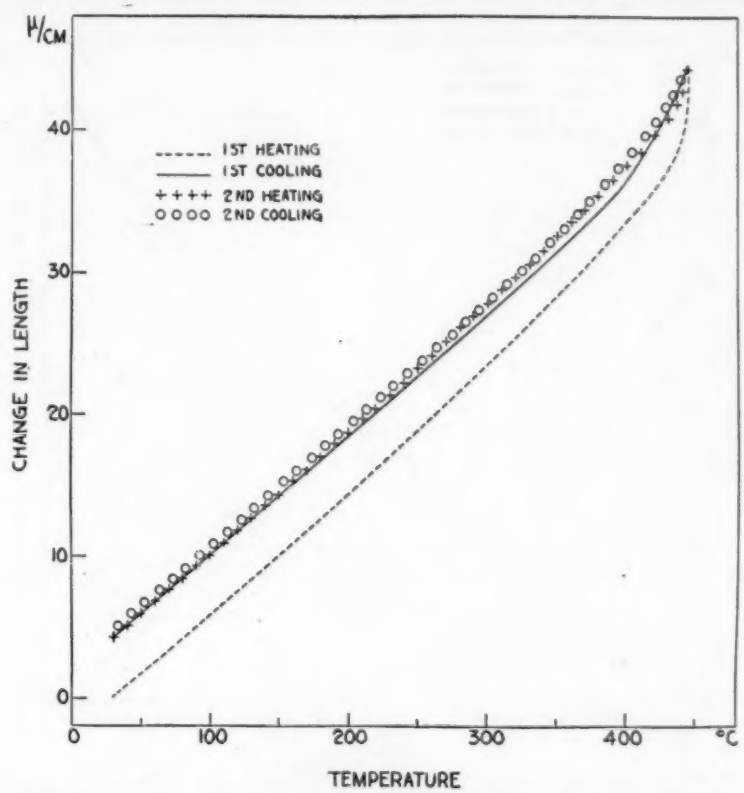

FIG. 3.—Expansion curves obtained on sample of glass untreated except for the usual cooling in the pot. For description of cycles see remarks under Fig. 2 and in text.

ing the first cooling shows only a relatively small return drift toward any equilibrium for a lower temperature; as a result the major part of the change at the holding temperature was retained until room temperature was reached and this change may, therefore, be termed a permanent one, although it is no more permanent than the opposite change which of necessity preceded it during the annealing treatment of the sample at 360°C. The second cycle of heating, holding, and cooling produced a slight additional increase, which was mainly due to the fact that the first holding

period was too short. In fact, experience would indicate that when starting with the glass in the condition of this sample both these cyclic treatments combined were insufficient to produce more than possibly nine-tenths of the change which would normally follow the establishment of complete equilibrium in this particular sample at 443°C. To attempt to gain the whole change would, however, be too tedious in an investigation of this

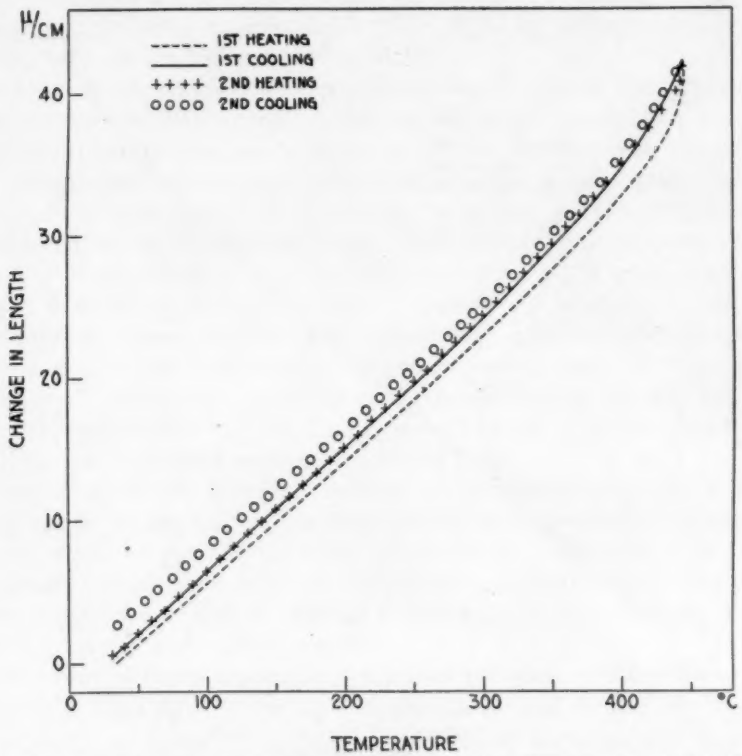

FIG. 4.—Expansion curves obtained on sample of glass treated at 420°C for 5 days and cooled in air. For description of cycles see remarks under Fig. 2 and in text.

sort. This is true since the process of approaching equilibrium is aperiodic, *i.e.*, it proceeds endlessly but at a continually decreasing rate.

Figure 3 represents the results obtained on specimens from the untreated sample. This glass was in a condition corresponding to equilibrium at a temperature slightly over 400°C, consequently, in this case also, a noticeable increase in the rate of expansion did not occur until 420° was reached. The change occurring at the holding temperature was not so great as in the previous case, but as before, the second cycle increased this permanent change slightly.

The next case was of interest because it had been previously estimated that the treatment involved in these heating and cooling cycles of the expansivity tests should be approximately the equivalent of an annealing treatment which would produce equilibrium at 420°C. This appears not to have been entirely correct since the curves in Fig. 4 (see also curve *E*, Fig. 7) appear to show that 430°C would have been a closer estimate, a con-

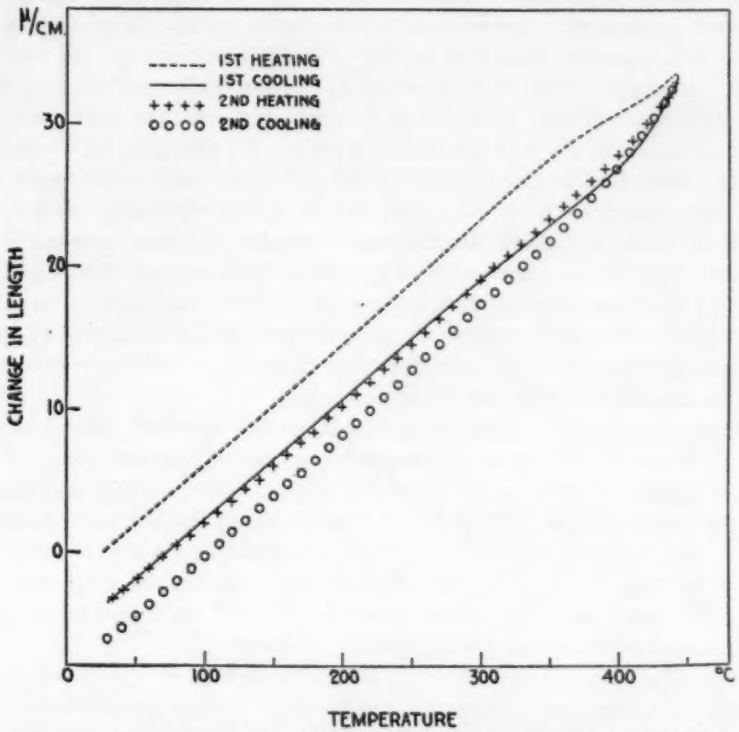

FIG. 5.—Expansion curves obtained on sample of glass treated at 470°C for 3 hours and cooled in air. For description of cycles see remarks under Fig. 2 and in text.

clusion supported by the curves obtained for the sample treated at 440° and represented in Fig. 7 by curve *C*. In Fig. 4, the permanent change in length after the second heating was unduly large in comparison to that found after the first. This may be due to either or both of two causes: either the holding period of the first cycle may have been too short or there may have been a slight difference between the holding temperatures. The latter appears more probable since to stop a steady rise in temperature of 3°C per minute abruptly at a given point without error requires, to say the least, considerable manipulative skill.

In Fig. 5, which represents the results obtained on the sample treated at 470°C, the condition was reached, as was also the case of that treated at 440°C, where there was no actual crossing of the equilibrium sequence *PQ* (which if incorporated in this figure should lie to the right) by the expansion curves. That is, the equilibrium temperature established by the treatment of the sample was above the holding temperature employed in these expansivity tests. In consequence, the specimens from this sample suffered permanent contractions after both cycles. The contraction began at temperatures as low as 350°C on the first heating. In measurements on samples such as these which have been chilled rather severely in the attempt to obtain a condition at room temperature which will correspond to a position well up on the sequence *PQ* (see Fig. 1), mechanical strains introduced by this treatment will usually be quite troublesome since they add considerably to the instability of the interferometer system and produce small disturbing displacements similar to those previously discussed. The effects produced by the strains, however, are almost as likely to cause an apparent expansion as they are an apparent contraction. Furthermore, if the test specimens are properly designed, these apparent length changes are in general very much smaller than the permanent contractions due to changing equilibrium conditions.

Figure 6 representing results obtained on the sample[13] quenched from 620°C shows a still more pronounced permanent contraction. In this case it appears to have begun below 250°C on the first heating, and reached such proportions near 350°C that it overshadowed the normal expansivity and changed it into an apparent negative coefficient for rising temperature. At the holding temperature this contraction continued for some time, and practically stopped only when physico-chemical equilibrium at 443°C was, from a relative standpoint, not far removed.

From Figs. 2 to 6 it will be noted that, as indicated by the curves for the second cycle, the total change in length caused by the normal expansivity on cooling from 443°C to room temperature was in all cases practically the same; that is, it was in the neighborhood of 41 or 42 microns per centimeter. This contraction caused by the cooling of the second cycle over this temperature range should obviously be the same for all of the samples, provided the first cycle was practically sufficient to produce in every case a normal equilibrium condition at 443°C. In view of this, it was possible with very little adjustment to construct a diagram which includes curves for all the various samples and in which all of the cooling curves for the second cycles practically coincide. Figure 7 is such a diagram and in it the curves *A*, *B*, *C*, *E*, *G*, *H*, and *I* correspond, respectively, to the results obtained on the first heatings of specimens from the samples treated at 620, 470, 440,

[13] This was part of the quenched sample used in a previous investigation, the results of which are being prepared for future publication.

420, 400, 390, and 370°C. Curve *F* corresponds to the original untreated glass, while the shaded portion, *D*, is so outlined that it is bounded in the majority of cases by the curves of the first coolings and contains those of the second heatings and coolings. It will also include the curves of all

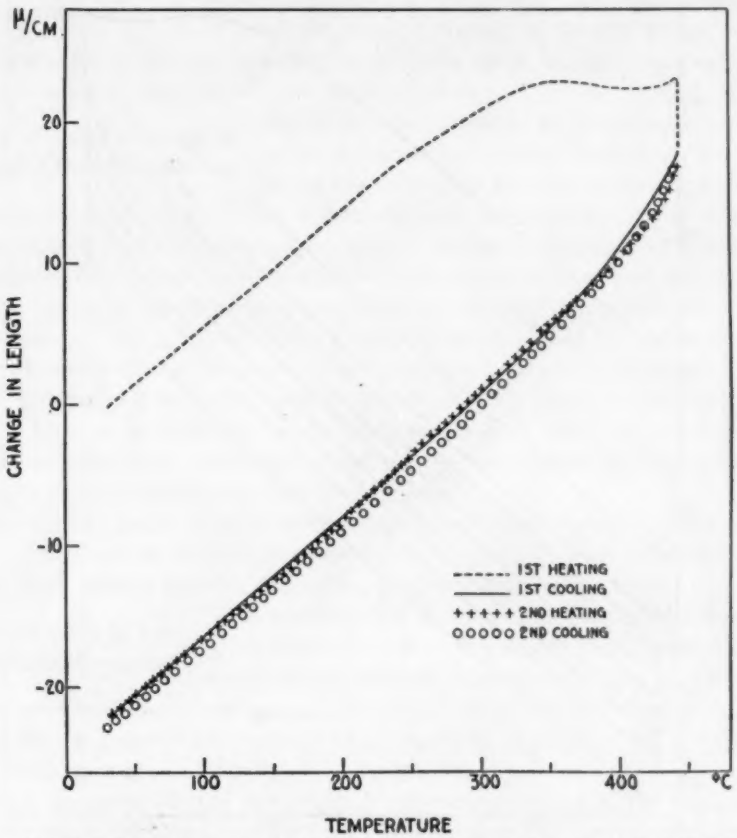

FIG. 6.—Expansion curves obtained on sample of glass treated at 620°C for 15 minutes and quenched in water. For description of cycles see remarks under Fig. 2 and in text.

succeeding cycles as long as the particular schedule used in these tests is followed. It will be evident that this whole diagram may be considered as occupying an area which in Fig. 1 is bounded approximately by the lines *A*, *A''*, *C''*, and *C*. It must be remembered, however, that Fig. 1 was constructed on the basis of more or less indefinite heating and cooling conditions and through the use of assumed values for the constants of the glass; that is, it is merely a generalization in which the constants were chosen mainly according to convenience as long as they did not appear unreason-

able. Consequently, a perfect correspondence cannot be expected, and for that reason the agreement obtained seems striking.

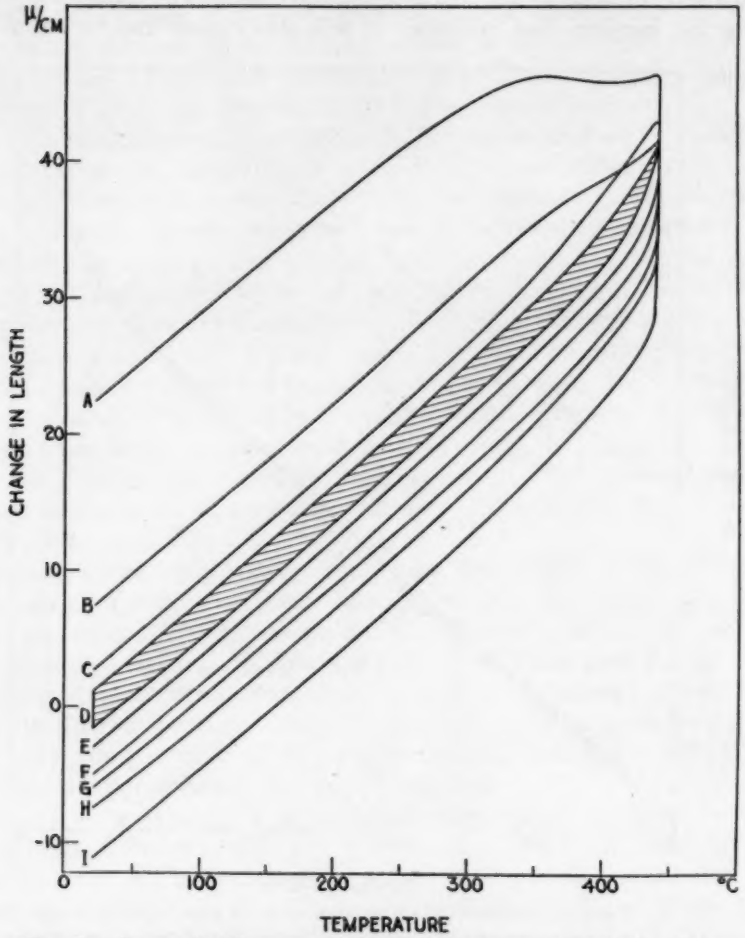

FIG. 7.—Composite diagram of the expansion curves obtained. Curves *A*, *B*, *C*, *D*, *E*, *F*, *G*, *H*, and *I* represent the first heating curves obtained on the samples previously treated at 620, 470, 440, 420, 400, 390, and 370°C. The sample corresponding to Curve *E* was untreated. The first cooling curves coincide roughly with the edge of the shaded portion, *D*, nearest the corresponding first heating curve. The cooling curves of the second cycle coincide approximately with a median line through the shaded portion.

IV. Concluding Discussion

The permanent changes in length noted after the test specimens from the various samples had been subjected to these treating cycles are indicated

in Fig. 7 by the ordinate differences at 20°C between a central position in the shaded portion, *D*, and the curves *B*, *I*, etc.

Total Volume Change by Direct Measurement

Taking into consideration all the determinations obtained on the samples treated between 370°C and 470°C, it was found that the indicated total permanent change in length which could be produced in this particular glass between these treating temperatures was between 17 and 18 microns per centimeter.

Total Volume Change by Density Determinations

While the magnitude of such a change cannot be determined by this method with the precision reached when the corresponding volume change is obtained from the determinations required in careful density measurements, it should still approximate the linear change which may be computed from these more precise volume determinations and which had previously been found to be very nearly 16 microns[14] per centimeter for a difference of 100°C in the treating temperatures. That this more precise value is lower than that above is not surprising since the density changes were determined on large samples which at high treating temperatures allow, because of their size, a relatively larger drift along the equilibrium sequence than that which was permitted by the smaller and more easily quenched samples used for this investigation.

One factor leading to greater precision in the density measurements arises from the fact that changes in shape have no effect on such measurements while they always present difficulties in linear expansivity tests.

Computation of Ice-Point Displacement

This medium flint is, of course, not a thermometer glass although tests have shown that its annealing range approximately coincides with the lead glasses often used in thermometer stems. For that reason it is interesting to compute the ice-point displacements which might be expected if both the bulb and stem were made from it.

Since the linear change per degree is approximately 1.6×10^{-5}, it is seen that in round numbers 5×10^{-5} may be considered as the volume change per degree change in the effective annealing temperature. As the differential expansion per °C for this glass and mercury would be about 1.5×10^{-4}, this means that for every degree reduction in the effective annealing temperature there will be a rise of $^1/_3$ °C in the ice-point.

If such a thermometer were carefully annealed at 400°C before being filled and calibrated to that point, it would later, on being held for a few hours at 390°C, which is presumably a safe point on the scale considering

[14] The approximate values for the change in density per °C decrease in the effective annealing temperature; the density and the linear expansivity are, respectively, 16×10^{-5}, 3.35 g./cm.^{3}, and 0.9×10^{-6} per °C. See Tool and Hill, *Trans. Soc. Glass Tech.*, 9, 199 (1925).

that it extends to 400°C, show a rise which might well exceed any tolerance ordinarily required.

Actual tests have shown that some of the 400°C thermometers on the market behave in just this manner. In fact, holding them in the range between 380°C and 390°C for two weeks will, occasionally at least, produce a displacement which exceeds +10°C. If the ice-point is determined both before and after use at these high temperatures such a change, since it occurs slowly, is, of course, not so important and becomes a mere nuisance. As a matter of fact, however, these thermometers should not be graduated higher than 350°C; and moreover, not to that point unless they have been so carefully annealed that the effective treating temperature has been brought well below 400°C.

Reducing the effective annealing temperature below the upper limit of the scale is of little benefit in the case of such thermometers if they are graduated to 400°, because if this temperature has been reduced to 380°, for example, any extended use of them at 390° will then produce a considerable ice-point depression.

Advantage of Bulbs Made of Higher Annealing Range

Using a low annealing range glass of this sort in the stem and a glass with the same expansivity but a higher annealing range in the bulb in order to reach 400°C has possibly, in relation to this particular type of ice-point displacement, some advantages but is also likely to cause difficulties of a somewhat different character. These will arise from the fact that it is impossible to anneal both glasses thoroughly, since to anneal the bulb properly would endanger the stem through softening; while if the stem alone is well annealed there will be throughout the annealing period a clamping effect upon the bulb at the line of fusion. This effect caused by the greater shrinkage of the stem will be difficult to eliminate, especially if it is introduced by annealing at relatively low temperatures; and as soon as the thermometer is used at temperatures above the effective annealing point of the stem, the consequent disannealing will reduce the effect and it may even introduce a temporary spreading effect. Such distortions of the bulb would naturally lead to erratic results, especially if the thermometer is employed at too high temperatures.

These particular clamping and spreading effects, which appear at junctions and which result during heating and cooling from differences in annealing temperatures, have a very wide significance wherever two or more glasses, which may even be only slightly different, are required in fashioning an article. In fact, it is evident that besides the normal expansivities, two other factors, the expansions (or contractions) caused by changes in physico-chemical equilibrium conditions and the annealing ranges, must be considered whenever two glasses are fused together. Even

in an article made entirely of one glass, the first of these two factors may assume considerable importance as a cause of breakage if the heat history of all parts of the article has not been the same, and particularly if the whole article is not properly annealed subsequent to its fabrication. This should be evident from the curves presented, since they show that the "permanent" change may easily exceed a sixth of the normal thermal expansion incurred in heating the glass from room temperature to the annealing range.

Difference between Expansivity and Permanent Volume Change

It will be noted that the normal expansivity of this glass as indicated by the slopes of the curves below the annealing range does not appear to vary greatly and that changes in the heat treatment do not affect it materially. What might seem to be a large variation at the higher temperatures has been shown to be due mainly to the "permanent" dimensional changes which have been the subject of this article and which are not related to the true expansivity of the glass. Any change in the equilibrium condition of the glass, however, should cause some change in the true expansivity, but normally this change in the expansivity is not likely to be more than a few per cent. In fact, it is to be presumed that the total effect which any such change in this coefficient might cause in cooling from the annealing range to room temperature would normally be less than the "permanent" change in length which is possible as a result of changing the equilibrium temperature through a relatively small interval.

Explanation of Fig. 1 Curve *PQ* represents the cooling curve (contraction per unit length) of a glass sample cooled so slowly that the glass follows its sequence of physico-chemical equilibrium conditions. At *P* a cooling rate of many degrees per second may be relatively slow while at *Q* a degree in many years may be very rapid when compared to the respective rates at which a glass that is removed to an appreciable extent from the equilibrium conditions corresponding to these points will approach stability. Curve *PE* represents the curve of a sample cooled very rapidly from 700 °C and from an equilibrium condition corresponding to that or higher temperatures; for example, small particles quenched from 700 °C in water. For a time the rate of cooling caused by the quenching is insufficient to prevent some drift along *PQ* but ultimately, near the temperature determined by the crossing of the curve *R*, this drift ceases and the curve proceeds in the direction *E*. The increasing angle which a tangent to curve *PE* makes with *PQ* indicates the decrease in the drift as the temperature falls, and the slope of the straight portion, *E*, represents the normal expansivity. Likewise, the remaining two solid circles represent water quenchings from the indicated temperatures and from equilibrium conditions at these temperatures. The first temperature is slightly above the range of curve *R* and before taking the direction, *D*, indicating a normal expansivity there is a slight drift in spite of the rapid cooling caused by quenching; but the lower one being below *R*, the drift is inappreciable and the normal expansivity, *C*, is followed.

If now a sample is quenched in air from 600 °C and from a condition represented by the open circle on the equilibrium sequence at that temperature, the physico-chemical condition of the glass will again drift considerably toward the equilibria of lower temperatures until the cooling curve approaches parallelism to the direction *D* at the approxi-

mate position indicated by the curve *M*. On air quenching from 500 °C with the glass in the condition indicated by the next lower open circle, the drift is relatively slight and the curve soon becomes parallel to *C* without further drift toward *PQ*. Glass in equilibrium conditions corresponding to the two remaining open circles will, on being air quenched from the indicated temperatures, follow respectively the normal expansivity slopes *B* and *A* without any appreciable drift toward the equilibria of lower temperatures. Samples of glass caused to follow curves *A* to *E* will have different densities; that following *E* having the least, and that following *A* the greatest. These limits are intended to show the maximum variation attainable by practical means.

If the samples of glass *A* to *E*, cooled as described, are heated very rapidly, *i.e.*, at rates of the order obtained by water quenching, the expansion curves *AA'P* to *EE'P* will be followed. Samples A, B, and C will, before crossing the curve *PQ*, show no appreciable drift toward the equilibria of lower temperatures but after crossing and becoming considerably superheated will ultimately drift to the equilibria of higher temperatures. This drift, however, will not be appreciable until the region limited by *R'* is entered. The samples *D* and *E* will, on the other hand, after reaching the region *R* drift toward the equilibria at lower temperatures until *PQ* is crossed, then they will superheat relatively little before drifting toward the equilibria of higher temperatures.

If, however, the samples *A* to *E* inclusive are heated at a much lower rate, the expansion curves will be represented by *AA"* to *EE"*. In such a case, samples *A* and *B* will show no appreciable drift toward the equilibria of lower temperatures before *PQ* is crossed and after crossing, the drift toward the equilibria of higher temperatures will be inappreciable only until the curve *S'* is reached. After crossing curve *S*, samples *C*, *D*, and *E* will drift toward equilibrium at lower temperatures until *PQ* is crossed. After crossing *PQ* a slight superheating will occur and then the drift toward the equilibria of higher temperatures will begin.

To picture the significance of the family of curves to which *R*, *M*, and *S* and *R'* and *S'* belong, they may be considered as contour lines on the map of a valley of a mountain stream emerging from a narrow gorge at *P* and which gradually widens to a broad and relatively level plain between curves *S* and *S'*. The altitudes so indicated would represent the rapidity of the drift toward *PQ* shown by glass at different temperatures and in conditions corresponding to different equilibria.

Corresponding diagrams may be constructed for any property affected by the changing physico-chemical conditions in any material having characteristics similar to those of glass.

DESIGN FOR ENAMEL SMELTING FURNACE[1]

By R. D. Cooke

ABSTRACT

Experiments with the construction of an open-hearth smelter are described which resulted in the design as described. The walls were made thin and the bottom supported on beams which exposed the entire outside of the hearth to the air.

Introduction

In the construction of this furnace there is nothing essentially new. It has become increasingly evident, however, that it is new to many enamelers.

With the exception of the rotary smelting furnace and some attempts at continuous smelting, the design of furnaces has followed very conservative lines. There is the solid foundation on which the hearth is laid, the heavily insulated walls lined with smelter brick, and the integral arch. Various refinements have been added in the form of special fuel applications, charging devices, and quenching paraphernalia. One of the aims of furnace building has been to secure good thermal insulation of the walls.

Furnace for Corrosive Enamel

Without Heat Insulation

In smelting a very special type of enamel, which was extremely corrosive and required high temperatures, the life of the furnace lining became a serious problem. Every available kind of smelter brick was tried without finding anything that was really satisfactory. It was finally decided to dispense with insulation entirely, the thought being that by exposing the lining directly to the air the outside would be kept cool and the temperature in the inside would not penetrate the lining as far as it would if the heat were not permitted to radiate. Confining the higher temperatures to the inner zone should keep the body of the refractory intact for a longer time. It should be realized in considering this point that although the average temperature of the lining is lower, the total heat passing through the lining, expressed in B.t.u. per minute, is considerably greater.

Twelve-Inch Tank Block

The first attempt involving this theory was made in the manner shown in Fig. 1, which is a cross-section of the furnace.

Two concrete piers were laid the length of the furnace, with the top surfaces sloped at the same pitch as was required for the bottom of the furnace. Across these piers a number of rails were laid, and these were shimmed to bring the tops into a plane. On these rails, the hearth of the furnace was built from refractory tank blocks twelve inches thick. The arch was supported independently from a steel shelf bracketed to the buck-

[1] Presented at the Annual Meeting, American Ceramic Society, Toronto, Ont., February, 1930 (Enamel Division).

stays. The purpose of this was to permit the bottom to be replaced without disturbing the arch.

The results from this lining were encouraging. The life was about three times that of the old insulated brick linings, but the cost of the blocks in-

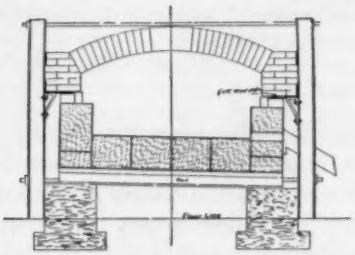

FIG. 1.—Smelting furnace. Cross-section, block lining.

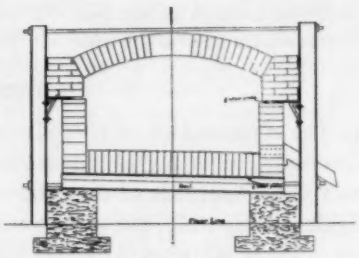

FIG. 2.—Smelting furnace. Cross-section, brick lining.

stalled was five times that of the brick lining installed, and so with this arrangement the desired economy was not realized.

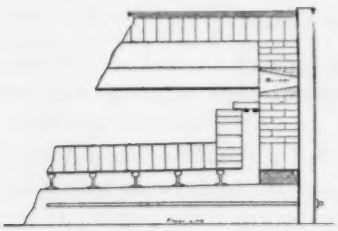

FIG. 3.—Smelting furnace. Longitudinal section.

Standard Nine-Inch Brick

Finding tank blocks out of the question on account of cost, a similar construction was attempted using standard nine-inch brick.

A plate of $^1/_4$-inch steel was laid on top of the rails. For convenience in handling, this was divided into a number of pieces. The hearth was built up on this plate with nine-inch brick as shown in Fig. 2.

Using one of the better grades of smelter brick the life of this hearth was slightly more than double that of the insulating lining and the cost somewhat less. The reason for the cost being less will appear presently. This furnace was therefore a decided economy, and repeated runs confirmed the result of the first.

Figure 3 shows the end construction. A number of detail drawings would be required to show it fully. There is a six-inch air space between the end of the hearth and the end wall of the furnace. This provides circulation of air for cooling the ends. It is covered

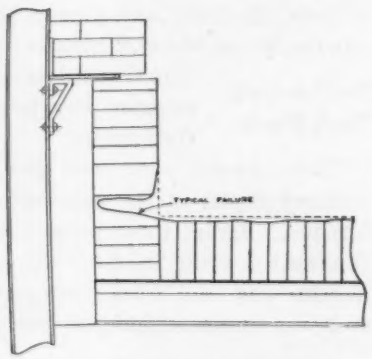

FIG. 4.—Smelting furnace.

over with a course of brick resting on two iron bars which in turn are supported by cross-pieces attached to the buckstays. The end wall is built with a low arch at the bottom to provide access to the space beneath the furnace and also to allow freer circulation of air around the bottom.

Figure 4 is an enlarged detail of Fig. 2 showing the nature of the failure in this lining. The dotted line indicates the original face of the brick and the full line, the face when failure occurs. It has been found practicable to take off the walls down to the three bottom courses and to renew them without disturbing the bottom. This is the reason for the less cost of this lining as compared with an insulated lining of the same size and the same kind of brick. The bottom may survive two or three sets of side walls.

Savings Made

Strangely enough the fuel consumption in this furnace was only slightly higher than in the insulated furnace. The difference was a matter of less than 5%. This means that even with relatively high radiation loss the total radiation is a very small part of the heat produced from the fuel.

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A STUDY OF SOLUBLE SALTS IN ENAMELS[1]

By R. D. Cooke

ABSTRACT

A study was made of the effects of a number of soluble salts on one type of sheet-steel enamel. The factors affecting the quantities and nature of the salts normally appearing in the enamel water were observed. The effects of these salts together with those of a number of added salts were noted from the standpoint of set-up of the enamel, rusting of the iron, and appearance of the fired enamel.

Introduction

Soluble matter in the water of wet-milled steel enamels is of two distinct kinds: those leached from the frit surfaces during and after milling and those added deliberately either at the mill or later.

Salts Leached from Frit

Type of Salt Of the former class, the writer has attempted on many occasions and on many types of enamels to secure complete information by chemical analyses. The only substances definitely identified in significant quantities have been sodium carbonate, sodium borate, sodium fluoride, sodium sulphate, and organic matter derived from the clay. Traces of silica, alumina, and sodium hydroxide have also been found. Fluoride is found, of course, only in enamels made with fluorine compounds. Nitrates, chlorides, etc., are found only to the extent that they may have existed in the water used.

On a type of enamel applied in one coat directly to the steel it was believed to be advantageous to have the soluble alkalis low, and the critical examination of this belief led to a detailed study of the salts present and of their effects. Some of the results of this study are summarized here.

Effect of Smelting Temperature A typical analysis of the water from this enamel was

Sodium borate	3.15 g./l.
Sodium carbonate	0.39 "
Sodium sulphate	1.34 "

A sample quite low in alkalinity was

Sodium borate	2.21 g./l.
Sodium carbonate	0.24 "
Sodium sulphate	1.42 "

The interest in the comparison of these two analyses is in connection with the smelting. Contrary to the experience of Cook,[2] it has been found that prolonged smelting tends to reduce the soluble alkalinity. The first analy-

[1] Presented at the Annual Meeting, American Ceramic Society, Toronto, Ont., February, 1930 (Enamel Division).

[2] H. L. Cook, *Jour. Amer. Ceram. Soc.*, **10**, 343 (1927).

sis is from a somewhat under-smelted frit and the second from a well-smelted frit.

It is of interest to note that in the harder smelted enamel the sulphate is higher. As there was no sulphate in the batch, it must be inferred that it was derived from the fuel oil and that with the harder smelting there was a higher partial pressure of sulphur oxides in the furnace.

Effect of Aging Analyses of forty samples of enamel water after aging gave results covering the following range:

Sodium borate	3.39–1.90 g./l.
Sodium carbonate	0.66–0.21 "
Ratio $\frac{\text{carbonate}}{\text{borate}}$	= 0.203–0.109

Effect of Salts It was of interest to know the effects of these variations on the finished enamels, but instead of selecting certain analyzed lots for trial, it was decided to prepare a lot free from soluble salts and add known amounts of the salts. This would permit covering a wider range of concentrations and also of investigating certain salts independently of the others.

A container of enamel was mixed with half its volume of condensed steam and allowed to settle, taking the clear water off the top. This was repeated until the alkalinity of the water was less than 0.05 gram of Na_2O per liter. The continued leaching of the alkalis was so persistent that it was not practicable to bring the alkalinity lower than that.

To portions of this enamel increasing amounts of borax, sodium carbonate, and sodium sulphate were added.

Effect of Borax Borax in quantities from 0.01 to 0.04 normal with respect to the water (1.01 to 4.04 grams per liter $Na_2B_4O_7$) had no important effect on the fired enamel. There was also no setting-up effect on the slip.

Effect of Sodium Carbonate Sodium carbonate in the same normalities (0.53 to 2.12 grams per liter) broke down the slip strongly and caused pronounced blistering around the edges of the piece when fired.

Effect of Sodium Sulphate Sodium sulphate in the same normalities (0.71 to 2.84 grams per liter) had no important effect either on the slip or on the fired enamel.

Conclusions The conclusion from these data was that the total alkalinity of the enamel water was not sufficient information on which to determine the blistering tendency of the enamel.

The carbonate was the harmful ingredient, and where this was found to be high, difficulty was avoided by adding to the enamel an equivalent amount of dissolved boric acid. This had the effect of shifting the equi-

librium toward lower carbonate and presumably caused the slow escape of carbon dioxide during drying.

Effect of Added Salts

Coming to the second class of salts, those added deliberately, we find a large number which might be considered, but in the case of one-coat enamels they are used for one or more of three purposes. They are used either to set up the slip to proper consistency or to cause or prevent rusting of the steel as the case may be for a one-coat mottled enamel or a ground coat, respectively.

For studying these effects the washed enamel was again used as the starting point. To portions of this enamel small additions of dissolved salts were made.

Sodium phosphate, sodium carbonate, and sodium fluoride had the effect of breaking down the enamel completely, allowing the frit to settle rapidly.

Borax, sodium sulphate, sodium chloride, sodium nitrate, magnesium sulphate, and cobalt sulphate had little or no effect.

Cause for Salts Setting-Up the Enamel

The above results were, of course, in the absence of any other salt.

If either borax or sodium carbonate was first added to the enamel, then magnesium sulphate and cobalt sulphate each had the effect of setting-up the enamel very strongly, but not the others. This shows that one type of setting-up is the result of a reaction in which a bulky insoluble compound is formed. In this case the reaction is

$$MgSO_4 + Na_2CO_3 = MgCO_3 + Na_2SO_4.$$

No salt had the effect of setting-up the enamel in the absence of all other salts. Only the mineral acids set the enamel under those conditions.

Prevention or Promotion of Rust during Drying

The washed enamel used without additions caused rust to form in small spots very close together. Cobalt sulphate, sodium thiosulphate, sodium sulphite, magnesium sulphate, and acids had the effect of promoting rust, making it appear more rapidly or causing it to become more intense.

Sodium carbonate, sodium sulphate, sodium fluoride, sodium chloride, and sodium nitrate had little or no effect on the rusting.

The practice of adding sodium carbonate to the mill in white ground coats, presumably to prevent rusting, evidently depends on its action in connection with some other salt already there if it really is in fact effective.

Sodium persulphate, borax, sodium nitrite, and sodium phosphate inhibited or prevented rusting.

Borax began to be effective at a concentration of 4.0 grams per liter. The effect of sodium nitrite was so remarkable that it was studied more in

detail. It was found that in concentrations as low as one gram per liter, which is 0.04% of the frit, rusting was, in most cases, completely stopped even with very slow drying. It had no effect on the set-up or on the finish of the fired enamel. It was found to be equally effective in cast-iron enamels. The application of this fact to the technique of light-colored ground coats and to one-coat colors is obvious. The other salts, persulphate and phosphate, were not studied quantitatively.

Summary

These data are very incomplete as far as covering the entire field of enamels is concerned, since all of the observations reported here were made on one enamel. All of the important conclusions, however, have been verified practically on a considerable variety of enamels. It seems safe to assume for the present as a general rule that the properties of set-up and rusting depend entirely on the nature and amounts of salts in solution in the enamel water and that the composition of the frit does not affect these properties except as it influences the soluble matter by being more or less soluble itself.

RUNDLE MANUFACTURING COMPANY
MILWAUKEE, WIS.

COST SAVINGS IN CONTINUOUS FURNACES[1]

By C. A. Dutton

ABSTRACT

The continuous furnace is replacing the box-type furnace because of its savings in labor, fuel, and floor space, its indirect savings in quality, production, and cost control, as well as its simplified supervision. It has also made further savings possible by the application of the continuous principle to other enamel shop operations, continuous spraying, for example.

The installation of more than fifty continuous enameling furnaces turning out stoves, refrigerators, hollow ware, signs, washing machine tubs, table tops, and general jobbing work all point the way to production economies in the enameling field.

These economies are labor saving, fuel saving, saving in floor space, improved quality, decreased inventories, and a minimum of supervision.

Continuous furnaces are built in sizes varying from two to eight or ten box-type equivalents.

The cost savings, naturally, will vary with the size of the furnace, continuity of operations, and local conditions. For example, a continuous furnace giving an average of three box-type equivalents, operating between ten and twenty-two hours a day, may show a saving of between ten and twenty thousand dollars a year in labor and fuel, not to mention the saving of two thousand square feet of floor space. Nor do the savings in this case include the intangible features of improved quality, production control, cost control, a minimum of supervision, and the tendency toward reduced labor turnover. In this analysis, the furnace capital investment would be approximately that of the three box-type furnace.

An example is cited of a continuous furnace which delivered an average of 1000 square feet of one-fire ware per hour and eliminated five operators. Another plant, averaging 2000 square feet of one-fire ware reduced its firing labor 60%. Still another furnace, delivering 4000 firings of hollow ware an hour replaced twenty-three operators.

The fuel savings vary from 30 to 50%. The greatest fuel economies are obtained with continuous operation as fuel for idling will vary from 40 to 60% of the operating heat input requirements.

The design and loading of the furnace tools, as well as the size and design of the furnace has its effect on the fuel consumption.

From these few examples it can be seen how direct savings in continuous furnaces vary from thirty to one hundred dollars a day on each furnace, and re-operations have been reduced in one plant to less than 2% and scrap to less than one quarter of 1%, while the per cent chipping in mounting is very low.

[1] Presented at the Annual Meeting, American Ceramic Society, Toronto, Ont., February, 1930 (Enamel Division).

The constant furnace control has made possible the closer control of other operations, such as spraying or milling by eliminating the former box-type furnace variables.

In enameling, as in other lines of manufacturing, it has been found that when fewer manual or mental operations are required, the results will be an increase in production as well as in improvement in quality.

With the batch furnace performance, for example, the fireman and his helpers usually brought the ware from some near-by point, loaded the furnace fork, charged the furnace, observed the firing, discharged the furnace, unloaded the fork, and racked the ware to be trucked away. Now, with the continuous furnace, the ware is fed to the furnace chain loaders, not necessarily by experienced operators who only transfer the ware from the feeding medium, or previous operation, directly into the furnace tool. Other operators act as furnace chain unloaders and may perform that one operation, or may also sort the ware, or even inspect the ware as their duty.

Thus, the batch furnace firing crew cycle of three minutes is cut to as little as three seconds per piece for the furnace chain loader or the unloader.

The furnace temperature is set and automatically controlled and the furnace chain speed set at predetermined constants.

The furnace design itself takes care of the gradual heating up and cooling off of the ware, which is the most desirable method of fusing glass on metal.

Thus it is that the continuous furnace minimizes the manual and mental operations in the firing cycle, which increases the productivity per man and improves the quality of the product. Installations have proved these points.

Improved quality has been mentioned. In a growing industry, like vitreous enameling, an improvement in quality will open up larger markets for enameled ware. Particularly then, at this time, is the continuous furnace important.

When production is ahead of consumption the buyer tightens up on inspection. To maintain the highest quality with the box-type furnace operation is usually costly.

With the continuous furnace quality is always maintained at a minimum cost.

In the past the continuous furnace has been regarded in some plants as a desirable luxury. Smaller installations have proved the success of the continuous furnace for almost all plants.

The plants operating the continuous furnaces will meet the quality demand with lowest costs.

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THE USE OF THE LINDEMANN-DANIELSON CROSS-BENDING TEST MACHINE[1]

By C. J. Kinzie and J. A. Plunkett

ABSTRACT

The effect of several variables such as enamel type, thickness of coating, fineness of milling, etc., are discussed and results are submitted. A special application of this machine is described in which it has been used in studies on the effect of dry film strength upon tearing in vitreous enamels.

Introduction

The machine described in this paper was built according to specification of the Committee on Standards of the Enamel Division, American Ceramic Society, with one exception; the machine was made 36 inches long in order to accommodate a greater number of test strips. With this machine tests can be made on 16 separate test strips at one operation.

The method followed in making the tests is essentially as recommended by the Committee, failure being taken as the first crack extending one-half or more across the piece.

Enameling of Strips

The standard practice used in the tests is to enamel in two coats of white, having a total of 7.8 grams white enamel, keeping the weight within 0.10 gram, plus or minus. Inasmuch as this is working within much narrower limits than usual, it may be of interest at this point to describe the method used in enameling.

The enamel is applied by the usual spray method.

A torsion balance is used having a capacity of about 5 kilos and a sensitivity of 0.1 gram under this load and with small loads, such as test strips, a sensitivity of 0.05 gram can be obtained.

The ground-coated strip is weighed. The enamel slip containing known amounts of solids and water is placed in a cup of spray gum.

A weight, equivalent to wet enamel required to yield 3.9 grams of dry enamel is added to the weight on the balance pan and, by spraying accompanied by several rough weighings, the required amount of slip is deposited. The piece is then dried and weighed again. If the weight is right, the piece is fired; if not, the enamel is washed off and the operation is repeated until the proper amount of enamel is deposited. With a little experience, there has been no special difficulty in obtaining coatings holding very close to 7.8 grams per strip. After firing, the weight is again taken and this final weight is used for record. The difference between the weight

[1] Presented at the Annual Meeting, American Ceramic Society, Toronto, Ont., February, 1930 (Enamel Division).

of the dry and fired film is slight. It is unusual by this method to have to discard a finished enamel strip.

The Effect of Enamel Type on Cross-Bending Strength

By using the cross-bending test machine the following pertinent facts as to the use of vitreous enamels have been established.

A number of commercial sheet-metal enamels used in enameling stoves, table tops, and refrigerators have been tested. The results show a great difference in resistance to cross-bending strength.

Enamel	1	2	3	4	5	6	7	8	9	10
Resistance to cross-bending (in.)	0.27	0.31	0.33	0.34	0.38	0.42	0.46	0.47	0.48	0.56

There is slightly more than 100% difference between the one having the lowest resistance and the one having the highest resistance. This should mean that under identical conditions as to weight per unit area, those enamels giving the higher cross-bending test would show a considerably lower assembly loss than those having lower resistance in this test. The evidence all points in this direction.

The testing machine to this extent has been of a definite value to the enameling industry. It has brought out in a manner expressible in numerical values, the fact that enamels vary widely in the combination of properties which results in lower or greater strength and puts into the hands of the enameler a tool by which he can determine the enamel best suited for his particular purpose. It also gives him a means of control testing which should be of definite value.

Effect of Enamel Thickness Resistance to Cross-Bending

Since the enamel thickness varies with the weight, the variations will be expressed by weight.

The following tests represent results with two different white enamels. Enamel No. 1 required a deposit of at least 10 grams for a good enameling job, whereas Enamel No. 2 gave practically equivalent opacity with about $5^1/_2$ grams.

Enamel No. 1			Enamel No. 2		
Test No.	Two Coats White Enamels (g.)	Av. Resistance (inches)	Test No.	Two Coats White Enamels (g.)	Av. Resistance (inches)
1	3.9	0.55	1	3.9	0.606
2	5.6	0.44	2	5.6	0.533
3	8.0	0.35	3	8.0	0.453
4	10.4	0.30	4	10.4	0.340

The above results are typical of a number of tests showing the effect of varying the enamel thickness on the resistance to cross-bending.

Effect of Fineness on Resistance to Cross-Bending

Several enamels, milled to different degrees of fineness, such as 12 to 6 and 0 grams plus 200-mesh from 100-cc. sample, applied on strips and tested, showed that as far as cross-bending strength was concerned there could be reasonable variation in fineness without seriously affecting the resistance to cross-bending strength.

Effect of Varying Mill Addition Opacifier Content on Resistance to Cross-Bending

Using one enamel, tests were made in which the opacifier content was varied in steps of 1% from zero to 10%.

The results showed only a slightly increasing strength from the zero to the 10% test, the average resistance in inches for the test with no mill-added opacifier being 0.47 inch. The resistance in one containing 10% opacifier was 0.540 inch. These tests show that for the particular enamel tested, the effect of varying the opacifier content would be a relatively unimportant one.

Conclusions

Considering resistance to cross-bending, the relation of differences in this property and the effect of these differences upon the enameling of metal, it appears that the pronounced difference lies in the various enamels in present use. It would seem that once this can be brought to the attention of the industry, the use of these enamel types having the greatest strength would be a natural result.

Considering the variable conditions affecting resistance to cross-bending for individual enamels, by far the most important is that of enamel thickness, showing that with vitreous enamels, the resistance decreases as the thickness of coating increases.

Special Application of Cross-Bending Test Machine

One enamel when fired in a continuous furnace tended to tear, whereas another enamel did not tend to tear under identical drying and firing treatment.

It was almost impossible to duplicate the actual plant conditions in the laboratory, for the reason that the shapes giving the trouble were large and flat.

The trouble was thought to be caused by distortion of shapes in transferring from driers to the furnace conveyer or while it was being heated, but at a temperature below that at which the enamel fused. In either event, the problem was apparently a difference in dry film strength of the two enamels.

The use of 12-by-2-inch strips was suggested.

The cross-bending machine was equipped with necessary accessories to test enamel films subjected to both concave and convex bending, as it was not certain which type of distortion might be the one encountered. To adapt the machine, four holes were tapped in top of the center or movable roll. Four hooks were made and threaded at the straight end and screwed into holes with each pair of hooks facing one another. (See Figs. 1 and 2.)

For concave bending tests, the center roll is raised to the point where the ends of the hooks are slightly above the tops of the stationary rolls, and the test piece which has the enamel wiped from the edges, is placed with the ends resting on the top of the stationary rolls.

By slightly lowering the center roll, the points of the hooks are brought

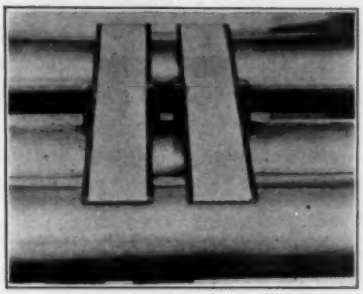

FIG. 1.

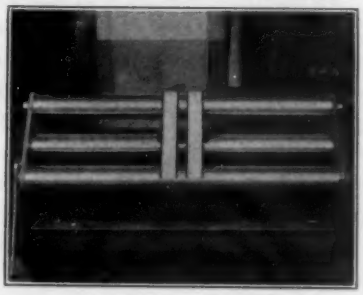

FIG. 2.

into contact. By this means, enamel, either in the form of dry film or fired enamels can be tested under concave bending.

This indicated that with dry films the convex bending tests were all that was needed, but it has been interesting to note the effect of this type of bending upon finished enamels. It is surprising to find that enamels will stand an enormous amount of distortion of this type, without chipping off or showing cracks, but when removed from the machine and brought back into the original shape, considerable cracking takes place or shows up.

In conducting the investigation relative to the effect of dry film strength upon the particular tearing problem referred to, the main subject was that of the effect of different enameling clays upon the dry film strength, since it was made known that different clays had been used in preparing the two enamels.

Using two enamel glasses, the slips were prepared with several brands of enameling clay.

Test strips, 12 by 2 inches, were coated with the test slips by the usual method at this plant, taking the precaution to maintain the enamel equal in amount.

The test pieces were subjected to definite degrees of convex strain and then fired, noting the point for each enamel at which the strain caused the enamel to tear when fired.

The fact was established that certain clays contributed a greater dry film strength than others.

It was shown in the case of the two enamels under investigation, that the difference was entirely due to the different clays used, and that each enamel made to slip with one clay gave weak films, whereas each enamel, when made to slip with another clay gave strong films.

As a result of this work, trials were made in the plant, and it was found that by changing the clay the requisite strength was obtained and the particular tearing problem was solved.

The machine was used in the above manner to determine the effect of enamel milling and the effect of fineness of milling upon dry film strength as well as its relation to tearing. In this way a check was made on the fact that the finer the enamel the greater is the tendency for the enamel to tear in processing.

The cross-bending machine has been of great service in these laboratories and it is believed that the extension of its use will be of great value to the enameling industry.

The originators of this machine and the Committee on Standards for the Enamel Division are to be congratulated for their work in the development and studies in the application of this machine to enamels.

THE TITANIUM ALLOY MANUFACTURING COMPANY
NIAGARA FALLS, N. Y.

PEBBLE MILL LININGS[1]

By Robert Twells

ABSTRACT

Pebble mill linings used in the ceramic industries consist chiefly of flint, quartzite, and porcelain blocks. Rubber linings have had considerable attention recently. The advantages and disadvantages of each type are discussed. Data are given showing relative costs at the Champion Porcelain Company of Belgian flint, "sillimanite" spark plug porcelain, and one-piece rubber linings. Of the first two, the porcelain showed the lowest cost per year of service. The test of the rubber lining is not complete, but its high initial cost practically eliminates it on that basis. For special purposes the additional cost of the rubber lining might be justified.

Introduction

Pebble mills have various types of linings depending upon the cost of the lining, its wearing quality, grinding conditions, and the nature of the material being ground. A lining may be of sectional or one-piece steel, sectional hard cast iron, wooden blocks, flint or quartzite blocks, vitrified porcelain blocks, vitrified brick, or sectional or one piece rubber. Some mills are used unlined in which case the shell is exceptionally heavy. Flint, quartzite, porcelain, and more recently rubber linings are of chief interest to the ceramic industries and this article will be limited to these.

Flint Linings[2]

Flint linings consist of roughly hewn blocks cemented in place. A large part of the blocks used are imported from Belgium being quarried at Maissières, near Mons. Slabs of rock are blasted from the side of the quarry; then cut by hand as uniformly as possible into thicknesses of 2, $2^1/_2$, 3, 4, and 5 inches. The dimensions of the blocks vary widely as the cutters try to eliminate porous spots and holes. The irregular shape of the blocks makes laying of the lining difficult and costly. The joints are necessarily wide and wear out quickly. A flint lining is rough but this in itself is not a disadvantage. The rough surface carries the pebbles higher in the mill and probably tends to give more efficient grinding. The hardness of the flint and the thickness of the cement makes the removal of the lining difficult and slow even with an air hammer. When the flint is very hard and uniform the blocks themselves wear well. There is likely, however, to be much difference in the hardness of the various blocks. Spots or streaks of calcite are often present which are soft and wear out rapidly.[3] The holes and cracks thus formed make hiding places for

[1] Presented at the Annual Meeting, American Ceramic Society, Toronto, Ont., February, 1930 (White Wares Division). Received March 3, 1930.

[2] Usually called Silex or Buhrstone.

[3] Blocks containing calcite may be discovered and eliminated by a routine test of dipping each block in a dilute acid solution.

unground material which appears at the end of the grind as oversize particles.

A flint lining, as a whole, may wear well, but often defective blocks and joints make it necessary to tear out the whole lining prematurely. The nature of the material being ground and the grinding conditions have, of course, a most important effect upon the life of the lining. For instance, at the Champion Porcelain Company, a continuous Hardinge pebble mill lined with flint blocks has been in regular use for about seven years, dry grinding calcine, andalusite and dumortierite, all hard abrasive materials. This lining is still in excellent condition. Scattered blocks are worn an inch or so thinner than the rest, but not enough to cause trouble. On the other hand, the same type of blocks used for wet grinding in batch mills lasted only about two years due to irregular wear.[4]

Quartzite Linings The other kind of siliceous lining consists of fine-grained quartzite blocks quarried near Jasper, Minnesota. The opening of the domestic deposit was brought about by the World War, which had greatly increased the difficulty of importing flint blocks from Europe. The quartzite blocks are cut 5 inches wide, 3, 4, or 5 inches thick, and 8 to 12 inches long depending on the requirements; $^1/_4$ inch is allowed on the edges as the maximum variation from a plane surface in order to keep the joints between blocks as thin as possible. According to Weigel,[5] the microstructure of the Jasper quartzite indicates that it likely would be tougher than the Belgian flint and more uniform, but its resistance to abrasion might be less as the individual quartz grains would tend to become detached from the lining. On the other hand, the Belgian flint would be more brittle and would tend to fail by chipping rather than by abrasion.

The presence of calcite in the Belgian block is also mentioned as a disadvantage. He reported that these conclusions seemed to be borne out in practice, and cited several service records which tended to show that the best Belgian blocks outwore the Jasper blocks, but the lower cost of the latter and their uniformity of size and texture made the actual cost per ton of ground material about equal with either. Our own experience with the Jasper block, while not as extensive as with the Belgian block, leads us to agree with the above conclusions.

Some of the objections to the flint block already cited also apply to the quartzite block; the Jasper block, however, is reported to have given

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[4] It should be stated that these experiences with the Belgian and Jasper blocks occurred chiefly before 1924. During and immediately following the war, conditions made it difficult to obtain a good siliceous block.

[5] W. M. Weigel, "Domestic Tube Mill Lining Successfully Meets Foreign Competition," *Eng. Mining Jour.-Press*, December 13 (1924).

excellent service in a large number of installations, in some cases as long as ten years.

Porcelain Linings

When contamination of the mixture being ground is an important consideration, a porcelain lining is especially desirable. Porcelain blocks are more uniform in size than siliceous blocks. They can be laid with thin cement joints less than $^1/_{16}$ inch thick. The laying cost is less as well as the cost of tearing out the worn out lining.

Some manufacturers make a tongue and groove joint in the porcelain blocks to prevent any possibility of the blocks slipping out. This precaution hardly seems necessary; in our case a simple key-shaped block has proved entirely satisfactory. The tapered sides of the blocks keep the cement joint of uniform thinness and prevent exposure of more cement as the block wears back.

It is questionable whether porcelain actually wears better than the best flint blocks but porcelain has the advantage of being quite uniform in structure, so that the whole lining wears more nearly equal. Care must be taken that the porcelain blocks are free from laminations and thoroughly matured; otherwise they will wear irregularly.

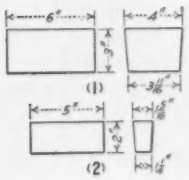
The dimensions of the blocks are important; the greater their thickness the longer they will wear; a larger block means less expense in installing the lining and fewer joints to give way. On the other hand the thicker the block the less will be the capacity of the mill. The larger blocks are also harder to make free from defects and uniformly fired.

If a mill is lined with blocks of uniform hardness there are several places in the lining that get irregular wear. The most abrasion is at the hub, which will wear thin before the rest of the lining. Other points of unequal wear are near the manhole and in the cylinder lining close to the end of the mill.

At the Champion Porcelain Company the whole cylinder lining tends to wear in grooves, owing to the uniform size of the pebbles. Here, porcelain blocks are pugged from the regular "sillimanite" spark plug body. After careful drying the blocks are fired to maturity in a Dressler tunnel kiln. The result is a block of uniform structure and high resistance to chipping and abrasion.

Two sizes (Figs. 1 and 2) of blocks have been used to line eight Abbé batch mills, each 6 feet in diameter and 8 feet long, in which the regular body and glaze mixtures are ground. Each mill carries a pebble charge of approximately 9400 pounds of "sillimanite" porcelain balls ranging from $1^1/_2$ to $^7/_8$ inches in diameter. Additional pebbles are added before each grind to maintain the level of the pebbles at a point 6 inches above the axis of the mill. The size of the mill charge is generally 3600 pounds, but this,

of course, varies with the nature of the materials being ground. The charge is wet ground for 20½ hours, the plastic materials being included only during the last hour. Including time for washing between charges, a mill will average 21 hours grinding out of 24 hours for five days a week. Under these conditions, the small porcelain blocks have averaged about four years of hard service as compared to about two years with the flint lining. The large porcelain blocks have run about six years and are still in use. These results are with blocks made from the "sillimanite" spark plug porcelain, which is extremely dense, tough, and homogeneous. While there is no information available on the subject, it is very doubtful whether an ordinary triaxial porcelain would wear as well.



FIGS. 1 AND 2.—Sketch showing sizes of porcelain blocks in use at the Champion Porcelain Company for lining Abbé pebble mills: 6 ft. diam., 8 ft. long.

Rubber Linings

Rubber can be fabricated into a one-piece lining of quite uniform wearing quality. The rubber lining is still in the experimental stage, but all indications point to a very long life.

The chief objection to the rubber linings are their high initial cost.

The friction in the mill, combined with the better insulating properties of the rubber tend to make the slip being ground much hotter than with other types of lining.

We have had more trouble maintaining standard conditions from mill to mill with the rubber lining, but are able to overcome this by slightly changing our grinding methods.

The rubber lining is thinner than other types and the capacity of the mill is correspondingly increased.

A flat rubber lining has no joints as hiding places for unground particles and can be cleaned out readily. This feature is especially desirable if the mill is used for grinding different types of bodies or dried out to change from wet to dry grinding.

A porcelain or flint lining dries out slowly, whereas a rubber lining dries out quickly.

Some have stated that rubber linings are undesirable for dry grinding owing to an accelerated aging of the rubber. At the Champion Porcelain Plant rubber linings have proved quite satisfactory for dry grinding, but in this case the mills are used for both dry and wet grinding and when not in use are kept filled with water. One mill has been handled in this way for over two years and is in excellent condition.

For general milling the present cost of the rubber lining hardly warrants its use, but for many special purposes the additional cost is justified. As a lining for mill covers, rubber fills a real need. It does not chip like

flint or porcelain and can be made to fit closer to the door frame, thus lessening the danger from underground particles at the finish of the grind.

COST DATA FOR VARIOUS TYPES OF MILL LININGS*

(A) Pebble mills (6 ft. diameter, 8 ft. long)
Used for wet grinding approximately 100 hours per week

(1) Flint block lining (3 in.) thick

2205 lbs. of blocks (1920 cost figures)			$121.27
Installing lining	2 bricklayers 1 helper	8½ days	261.63
Removing lining	two laborers	5 days	55.25
		Total cost	$438.15
Approximate life 2 years (cost per year)			$219.07

(2) Porcelain lining (small blocks 2 in. thick)

4000 blocks at $62.64 per M			$250.56
Installing lining	2 bricklayers 1 helper	6½ days	200.32
Removing lining	1 laborer	2½ days	13.67
		Total cost	$464.55
Approximate life 4 years (cost per year)			$116.14

(3) Porcelain lining (large blocks 3 in. thick)

1240 blocks at $383.00 per M			$474.92
Installing lining	2 bricklayers 1 helper	5½ days	169.40
Removing lining	1 laborer	2½ days	13.67
		Total cost	$657.99
Approximate life 6 years (cost per year)			$109.66

(4) Rubber lining (one piece 1 in. thick)

Cost of 1 inch thick lining including sandblasting the interior of the mill	$2137.19

This lining was installed April, 1929, and seems to be wearing well.

(B) Pebble mills (2½ ft. diameter, 3 ft. long)
Used for both dry and wet grinding about 50 hours per week

(1) Porcelain lining (small blocks 2 in. thick)

652 porcelain blocks at $62.64 per M			$40.86
Cost of installing lining	1 bricklayer 1 helper	2½ days	45.41
		Total cost	$86.27

Lined July, 1924, still in use.

(2) Rubber lining (one piece ⅛ in. thick) $298.13

Lined June, 1927, still in use.

* The data given can be considered as approximately correct only under the labor and milling conditions at the Champion Porcelain Company.

Conclusions

Flint, fine-grained quartzite, porcelain, and rubber have all given excellent results for pebble mill linings. Each type has its inherent advantages and disadvantages, which must be considered in relation to a particular grinding problem. A big factor in the choice should be the ultimate cost of the lining per ton of material ground which must include the relative loss of productive time while the mill is being relined.

Acknowledgment The writer wishes to acknowledge gratefully the suggestions of J. A. Jeffery, President, and F. H. Riddle, Research Director at the Champion Porcelain Company during the preparation of this paper, and to express his thanks to George Blumenthal of the Vitro Manufacturing Company and H. F. Kleinfeldt of the Abbé Engineering Company for helpful information.

CHAMPION PORCELAIN COMPANY
DETROIT, MICHIGAN

A STUDY OF THE CONSISTENCIES OF RAW TERRA COTTA GLAZES[1]

By L. D. Fetterolf

ABSTRACT

For measuring consistencies of glazes, a method was used based on the conception of glazes as plastic materials. A normal glaze thinned during the entire period of testing, being attended by a large decrease in yield value and a moderate increase in mobility. Use of an aged clay slip as a source of clay did not change the plastic properties or aging characteristics of the glaze. Heating a freshly milled glaze resulted in a consistency comparable with that developed by aging a normal glaze for a month. Water solubilities of glaze materials were determined as well as character and concentrations of soluble salts in mill liquors and p_H values of mill liquors. Solution of salts was progressive over a period of time and increasing alkalinity was probably the cause of spontaneous thinning. Gum arabic in proper amount was found to stabilize glaze consistency satisfactorily. Effects of acid, alkali, and water additions to gum-bearing and gumless glazes were studied.

Introduction

Published studies of glaze consistency have been based on the assumption that aqueous suspensions of glaze materials obey the laws of viscous flow. Although the fallacy of this assumption is realized, tests on glaze consistency are still largely made by observing the time of flow through some form of viscosimeter compared with the time for outflow of water or a liquid of known viscosity. Such measurements are easily made and may serve for purposes of control. In view of the recent developments, however, resulting from studies of plastic flow, it is of interest to consider glaze suspensions as systems possessing plastic properties.

An editorial[2] of January last calls attention to the newly named science of rheology and points out the need for application of its fundamentals to ceramic research.

The instability of glazes with respect to consistency and the frequent manipulation of consistency necessary to obtain proper spraying qualities are known. Bowman[3] has reported the results of an investigation of spontaneous changes in glaze consistency and of factors influencing consistency. His results are derived from measurements applicable to viscous materials and are expressed in terms of absolute units of viscosity. Thompson[4] and Spurrier[5] have also published papers relating to glaze consistency using the hydrometer and viscosimeter tests, respectively. The present paper dupli-

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[1] Presented at the Annual Meeting, American Ceramic Society, Toronto, Ont., February, 1930 (Terra Cotta Division).

[2] *Bull. Amer. Ceram. Soc.*, **9** [1], 1 (1930).

[3] *Jour. Amer. Ceram. Soc.*, **10**, 508 (1927).

[4] *Ibid.*, **12**, 581 (1929).

[5] *Ibid.*, **12**, 577 (1929).

cates, in part, the studies of the investigators named, but presents results obtained by a test method applicable to plastic materials.

Viscous and Plastic Flow

Viscosity is a property of fluids which yield steadily to the smallest deforming forces. If, considering the discharge of such a fluid through a flow tube, the rate of flow is plotted against shearing stress, a straight line is obtained which intersects the axes at the origin. The slope of the flow curve becomes a function of the viscosity of the fluid and viscosity may be expressed by a single numerical value.

A glaze differs from a truly viscous fluid in that it is comprised of (1) a coarse mechanical suspension, (2) colloidally dispersed materials, and (3) water containing small quantities of molecularly dispersed salts. By plotting rate of flow of such a suspension against shearing stress, it is found that the extrapolated flow curve intersects the pressure axis at a point to the right of the origin. The consistency of a glaze is, therefore, defined by two values: the slope of the curve and its intersection with the pressure axis.

The two factors involved in consistency have been termed "yield value" and "mobility." Yield value is the force required to produce motion of one layer of suspended particles relative to that of an adjacent layer and at present is arbitrarily measured by the intercept of the flow curve on the pressure axis.[6] Mobility is analogous to the reciprocal of viscosity and is measured by the rate of flow produced by forces in excess of the yield value. The slope of the flow curve is accordingly an index of mobility.

Apparatus and Calculation of Results

The apparatus used for consistency measurements consisted of a 100-cc. burette, the end of which had been cut off and a capillary tube of known dimensions inserted. For more detailed information with respect to apparatus, method of test, and other considerations, reference may be made to the publications of Cooke[7] and Harrison.[8]

To plot a plastic flow curve, calculation of the shearing stresses, F, producing flow is necessary. This is given by the formula:

$$\frac{Rhdg}{2l}, \text{ where}$$

R = radius of capillary (cm.)
l = length of capillary (cm.)
h = av. height of glaze (cm.)
d = density of glaze
g = gravitational constant

[6] The question whether the intercept of the extrapolated flow curve represents true yield value is one still subject to discussion by rheologists.

[7] *Jour. Amer. Ceram. Soc.*, **7**, 651 (1924).

[8] *Ibid.*, **10**, 970 (1927).

A numerical value for mobility is obtained by use of the formula:

$$\text{Mobility} = \frac{r}{F - f} \cdot \frac{4}{\pi R^3}, \text{ where}$$

R = radius of capillary (cm.)
f = yield value (dynes/cm².)
F = that force in dynes/cm.² corresponding to a particular rate of flow, r, chosen on the flow curve.

Procedure

The glaze used throughout this work was one of the Bristol type mentioned by Wilson[9] in his Monograph on Terra Cotta. The composition was as follows:

Feldspar	64.3%
Flint	2.1
Whiting	8.9
Calcined zinc oxide	15.0
Clay	9.7
	100.0

All factors which might affect consistency were uniformly controlled insofar as possible. Different glaze batches were given the same milling treatment and water contents were carefully adjusted. Glazes were aged in tightly-stoppered flasks in a constant temperature box held at the temperature at which consistency determinations were made.

Consistency Changes with Aging

The first observation made was on the consistency changes of the glaze with aging. Tests were made at intervals over a period of 32 days. The results are shown graphically in Fig. 1, from which it is evident that the glaze underwent a marked change in consistency. The yield value decreased and the mobility increased throughout the aging period as indicated by the approach of the flow curves toward the origin and their increasing slopes. After 3 or 4 days of aging, the glaze probably possessed proper spraying consistency. Prior to that time the yield value was much too high for good workability. After 4 days, thinning was so pronounced that preferential settling occurred.

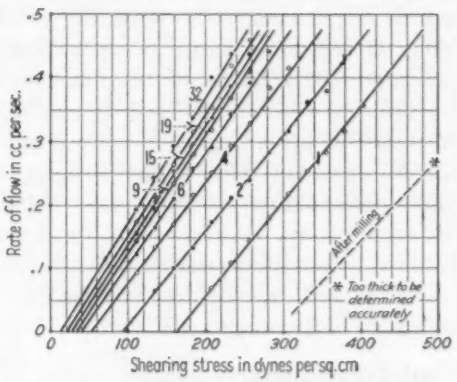

FIG. 1.—Consistencies of normal glaze over period of 32 days.

[9] *Bull. Amer. Ceram. Soc.*, **5**, 115 (1926).

In Fig. 2, the numerical values for yield values and mobilities of this glaze are shown plotted against time of aging in order to show comparisons which will be discussed later.

Investigation of Causes of Thinning

The spontaneous thinning of glazes causes so much difficulty that the problem merits attention. The use of an aged clay slip in glazes and heating of the glazes in order to stabilize consistency have been investigated by Bowman.[10] The same experiments were performed during the present investigation in order to note the effects on plastic properties of such glazes. Spurrier[11] attributes thinning to an increase in alkalinity upon aging. The results which are to be discussed may have some bearing on this theory.

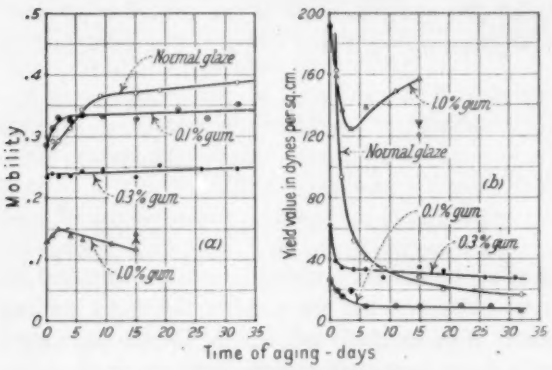

FIG. 2.—Aging behavior of glazes.

Use of Aged Clay Slip Inasmuch as thinning is a colloidal phenomenon it seems plausible that the use of an aged clay slip in a glaze might decrease the extent of thinning. Without doubt, aging of wet clay does produce colloidal changes. Were these changes produced in the clay before being used in a glaze, it might be presumed that the thinning which follows milling would occur during the milling operation. A glaze was accordingly made up using clay slip that had been aged for several months. After 1 day of aging, the glaze had a mobility of 0.280 and a yield value of 145 dynes/cm.^{2} After 32 days, the values were 0.39 and 14, respectively. Reference to Fig. 2 shows that these values conform to those obtained for a glaze in which air-dry clay was used. Evidently, the use of an aged clay slip does not change the plastic properties of a glaze and the cause of thinning is not inherent in the clay alone.

Heat-Treated Glaze Subjecting a sample of freshly-milled glaze to a temperature of 100°C for 1 hour immediately brought the glaze to a mobility of 0.38 and a yield value of 30 dynes/cm.^{2} Save for a slightly higher yield value this is equivalent to aging for a month. The effect of heat may be that of increasing the solution of salts

[10] See footnote 3.

[11] See footnote 5.

of a deflocculating nature or that of developing forces which break down clay aggregates.

Solution of Salts from Glaze Materials

If increasing alkalinity is the cause of thinning, the alkaline salts must be derived from the glaze materials. Water solubility determinations were made on each of the glaze materials using an arbitrary method employed in the New Jersey Zinc Laboratories for determining water soluble salts in ZnO. The results were as follows:

Silica	0.08%
Whiting	0.13
Feldspar	0.08
Calcined zinc oxide	0.02
Clay	0.01

The determinations were made on materials as received; therefore, the water solubility of milled materials would probably be greater because of increased surface areas. The low value for clay must be due to its high colloid content and the strong adsorptive power of the clay colloid.

The quantity of water soluble salts present is such that were they salts of the proper nature extreme flocculation or deflocculation might result. It is probable that some of the salts have little or no effect on consistency and the flocculating and deflocculating tendencies of the effective salts tend to neutralize each other. The net result is, however, that of deflocculation.

Qualitative analyses of the water-soluble salts in the materials listed were not made. Quantitative analyses, however, were made on salts contained in the mill liquors drawn from glazes after aging 1, 5, and 10 days and qualitative tests were made on the salts. The liquors were somewhat turbid when drawn off but after remaining undisturbed in the containing flask for a week, clear liquor was pipetted off. Analyses showed the salt contents to be 0.41, 0.42, and 0.44 gram/liter, respectively, for the liquors. These concentrations are low as checked against the concentrations which might be expected to result from the use of the materials for which solubilities have been given. This is not surprising for the strong adsorptive power of colloidal materials, particularly clay colloid, is well known.

Mill liquor drawn from the heat-treated glaze had a soluble salt content of 0.50 gram/liter. In this connection it will be recalled that this glaze had, after heating, a consistency comparable with that of a glaze aged 30 days.

A qualitative analysis of the salts determined quantitatively showed the presence of sodium and potassium salts as well as small amounts of calcium, iron, and aluminium salts.

Determinations were made of the p_H values of the mill liquors using the colorimetric method. Values found were 8.0, 8.1, and 8.3, corresponding to liquors drawn from glazes aged 1, 5, and 10 days. While these values

certainly do not represent the p_H values of the glaze suspensions, they are indicative of the equilibrium condition attained by the mill liquors.

These results would seem to indicate that solution of salts is progressive over a long period of time and that an increasing alkalinity is the cause of thinning.

Effect of Gum Arabic on Consistency

The literature contains references to the use of gum arabic in glazes for its adhesive and suspensive properties. No data, however, have been found which point out quantitatively its effects with respect to consistency.

A glaze was made containing 0.1% of gum arabic on the basis of dry weight of glaze, the gum being dispersed in water and added at the mill. Yield values and mobilities of this glaze over a period of time are plotted in Fig. 2. Comparison of the curves for this glaze with those for the normal glaze, given in the same figure, shows marked differences in consistency. The yield value is greatly reduced, mobility is decreased slightly, time-changes in the two factors are much smaller and these changes are completed in shorter periods of time.

The effect of 0.3% of gum is much more interesting in that it appears to stabilize the glaze satisfactorily with respect to consistency. Referring to Fig. 2, it is seen that mobility is lowered as compared with the normal glaze but the mobility undergoes practically no change with time. The yield value also remains practically unchanged after one day of aging, the initial small decrease in yield value probably being due to the release of occluded air. This glaze was judged to be of proper spraying consistency over the entire period of aging.

The effect of deflocculating salts is that of decreasing yield value and increasing mobility, bringing about in a short time the changes produced by aging a normal glaze. We might expect gum to act as a deflocculent, inasmuch as it carries a negative charge when suspended in water. It acts, however, like a deflocculent in decreasing yield value but unlike one in that at the same time it decreases mobility. No doubt gum is a deflocculent in proper amount, but mobility is decreased by reason of the higher viscosity of the water-gum dispersion medium. That gum stabilizes the consistency of a glaze is due to the protective nature of the gum colloid, which either nullifies the effect of increasing alkalinity of the glaze or by adsorption on the surfaces of the particles of solids prevents the solution of salts soluble in water.

The effect of 1% of gum is also shown in Fig. 2. This large amount of gum produced a decided gelled condition in the glaze. Thinning occurred over a period of 5 days followed by thickening. The consistency was largely determined by the degree of agitation of the glaze before testing. Agitation of the glaze, as uniformly practised throughout the work, gave

the consistency curves shown. Following the 15-day test, the glaze was agitated until no further change in consistency took place. The consistency then corresponded to the thinnest consistency developed by aging of this glaze. This suggests the possibility of controlling the consistency of a high gum glaze merely by agitating and breaking down the gel structure to the point desired. The objection is the high water content which would be required to develop proper spraying consistency.

Effect of Acid and Alkali

In Fig. 3 are shown the plastic flow curves for 300 g. portions of glazes to which had been added $N/5$ NaOH, $N/5$ HCl, and H_2O in the amounts indicated. The glazes had been aged 6 days before the additions were made in order to bring them to the same yield value.

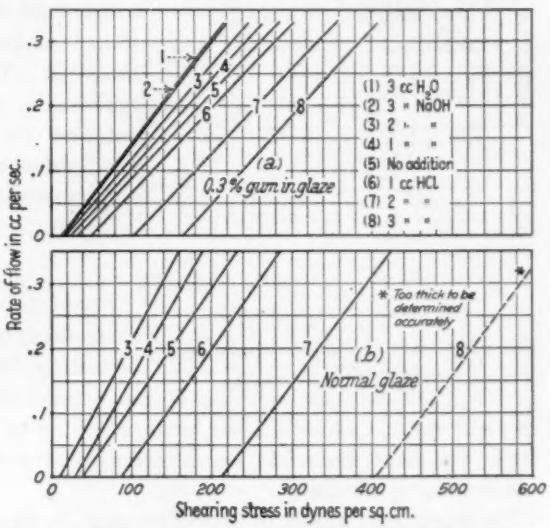

FIG. 3.—Effects of additions of $N/5$ NaOH and $N/5$ HCl; additions made to glazes aged 6 days.

The effect of additions of alkali to 0.3% gum glazes (Fig. 3*a*) was the same as that of the addition of water, *i.e.*, decrease in yield value and increase in mobility. This is in harmony with the previous finding that the glaze containing this percentage of gum was immune to the normal effect of increasing alkalinity with aging. Acid additions were quite effective in increasing yield value but mobility was not appreciably affected.

The same additions to a normal glaze had more marked effects as indicated by the more widely spaced curves. One cc. of $N/5$ NaOH was sufficient to produce deflocculation. Acid additions increased yield value enormously but had no effect on mobility.

The stabilizing effect of gum was shown by tests on the glazes after aging (Fig. 4*a*). The flocculated, gum-bearing glazes showed reductions in yield value but not as great proportionately as the reductions in yield value in the case of the flocculated, gumless glazes.

Practical Considerations

There has been no opportunity for correlating consistency in terms of

yield value and mobility with the spraying qualities of a glaze. It is believed that the two values are distinct properties of glazes and for proper consistency should fall within defined limits, those limits depending on the working properties required of the glaze.

Yield value is particularly important in the case of dipped ware inasmuch as it determines the thickness of the glaze coating which adheres. Mobility determines the rate of drainage of the excess glaze from the ware.

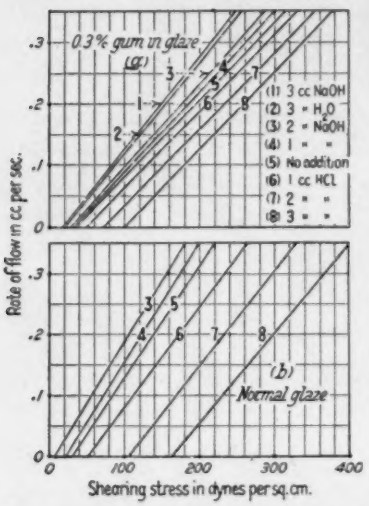

FIG. 4.—Glazes of Fig. 3 aged 6 days after additions.

While dipping as a method of application is probably unknown in terra cotta work, similar considerations of glaze behavior may be applied to spraying. The yield value should be sufficiently high that the glaze will not flow on the ware. An excessive yield value would tend to cause non-uniform glaze thickness and poor leveling qualities.

Summary

Spontaneous thinning of a normal glaze occurred over the entire period of testing, being attended by moderate increase in mobility and great decrease in yield value. Evidence has been presented to show that solution of salts from the glaze materials was progressive and that thinning was caused by increasing alkalinity.

By using gum arabic in proper amount, it was possible to stabilize glaze consistency satisfactorily. The action of gum is apparently that of protection against deflocculation by moderate amounts of alkaline salts. Gum acted similarly to alkaline deflocculatives only insofar as it affected yield value.

Gum glazes were less susceptible to flocculation by acids than were gumless glazes. The effect of acid, however, on the former type of glaze was more persistent.

THE NEW JERSEY ZINC CO.
PALMERTON, PA.

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Abrasives

Compensating costs in grinding varied size billets. L. C. GRIFFIN. *Abrasive Ind.*, **11** [7], 20–21 (1930).—A practical method is outlined by which the tonnage of steel billets ground can be figured on a fair basis. Heretofore but little attention has been paid to the billet sizes which is an important factor in computing the grinding costs. E.P.R.

Disk grinding assures flat work. ANON. *Abrasive Ind.*, **11** [7], 21–22 (1930).—Some disk-grinding operations at the Chaplin-Fulton Mfg. Co., on gas regulators which are built in sizes from 1 to 24 in. and for pressures from 1 oz. up to 2000 lbs. are illustrated and described. E.P.R.

Mower parts ground accurately. HERBERT R. SIMONDS. *Abrasive Ind.*, **11** [7], 24–25 (1930).—The method used at the Coldwell Lawn Mowers Co. for grinding mower parts is described. E.P.R.

Lapping tungsten carbide tools. H. J. WILLS. *Abrasive Ind.*, **11** [7], 25–26 (1930).—The Carborundum Co. has developed an abrasive compound which permits fast and inexpensive lapping of tungsten carbide. An outline of procedure for its use is given. E.P.R.

Grinding effects economies in dressing high-speed tools. ANON. *Abrasive Ind.*, **11** [7], 26 (1930).—Rough-turning and finishing tools, for both right hand and left hand turning, and in sizes up to $1^1/_4$ x $2^1/_4$ in. are ground to the correct shape with bakelite wheels, No. 16 grain, grade T6. The rate of wear of the wheels on this work is slow. E.P.R.

Duplex wheels effect grinding economies. ANON. *Abrasive Ind.*, **11** [7], 27–28

(1930).—The more rigid cylindrical grinders permit use of duplex grinding wheels. By grinding two diameters at the same time, the production is doubled. Some of the applications of this method of grinding and the economies derived from it are shown, using both center and centerless grinders. E.P.R.

Grinding bar stock on new type centerless machines. ANON. *Abrasive Ind.*, **11** [7], 29–30 (1930).—A new type of machine was developed in Sweden to meet the need for handling stock up to 8 in. in diameter and 15 to 20 ft. in length. This article illustrates and describes some of the methods developed to adapt its centerless grinding machines to the finishing of hot-rolled bar stock. A hot-rolled tube, which previously was reeled, turned, and ground in two hours now is ground in 30 min. A large stream of cooling lubricant must be directed between the grinding wheel and the work. E.P.R.

Large disk grinder finishes heater sections. ANON. *Abrasive Ind.*, **11** [7], 39 (1930).—A double-spindle grinding machine carrying two wheels 6 ft. in diameter and said to be the largest machine of its kind ever built has been installed at the Spencer Heater Co., for finishing sectional heaters. The sides of the sections at the joints are finished flat. E.P.R.

Tungsten-carbide tool grinder. ANON. *Abrasive Ind.*, **11** [7], 40 (1930).—A new motor-driven wet cup-wheel grinder is especially designed for the grinding of tungsten-carbide tools. An adjustable table is provided to facilitate the grinding of correct rake and clearance angles on tools. The cooling medium is supplied by a friction-driven centrifugal pump which forces the coolant against the wheel. The weight of the grinder is approximately 1100 lbs. E.P.R.

Snagging machine grinds large material. ANON. *Abrasive Ind.*, **11** [7], 40 (1930).—A heavy-duty, high-speed snagging machine with an unusually large work table extending 16 in. back from the wheels and approximately 85 in. long, uses 36-in. wheels running at 9500 surface ft. per min. E.P.R.

Air-driven portable grinder. ANON. *Abrasive Ind.*, **11** [7], 41 (1930).—The operation of a portable grinder depends upon the rotation of four vanes mounted on a spindle which rotates within a casing having suitable openings for the admission and escape of compressed air. The efficiency of this tool depends upon even distribution of air upon the vanes. The new grinder is governor controlled and has little vibration. The tool is designed for 8- x 1-in. rubber or elastic bonded or 6- x 1-in. vitrified wheels. It is furnished with either a straight or pistol grip handle and with 6-in. or 8-in. wheel guard. The machine weighs 16 lbs. E.P.R.

Base design features new buffing lathe. ANON. *Abrasive Ind.*, **11** [7], 44 (1930).—A new single-spindle, variable speed buffing lathe is intended to give maximum convenience in working. The wheel spindle is driven by a multiple drive made up of V-belts from the motor. The spindle, which runs on ball bearings throughout, is of high-carbon steel, of large diameter. E.P.R.

Grinding and polishing alloy steel. ANON. *Abrasive Ind.*, **11** [7], 44 (1930).—Chrome-nickel corrosion and heat-resistant steel made by licensees of the Krupp Nirosta Co., Inc., can be ground and polished readily. The amount of grinding and polishing required depends largely on the mill finish of the sheets used. The best method is to use a soft grease wheel covered with a manufactured abrasive. Speeds for grinding should not exceed 8000 ft. per min., 6000 to 8000 ft. being best. For buffing, a speed of about 9000 to 10,000 ft. per min. should be used. All grinding and polishing should be done with the least possible pressure. E.P.R.

Device reduces labor in polishing. ANON. *Abrasive Ind.*, **11** [7], 46–47 (1930).—Supporting chains and springs are used for polishing motor stators and permit speed and flexibility of handling. This device at the same time lessens the burden on the grinding operator. Illustrated. E.P.R.

Gooseneck design in new buffer. ANON. *Abrasive Ind.*, **11** [7], 46 (1930).—On a gooseneck type buffing and polishing machine, the spindle and buffing wheels extend out from the base of the machine to permit easy handling of large or odd-shaped pieces. E.P.R.

Electric bench grinder. ANON. *Pit and Quarry*, **19** [2], 122 (1929).—A new 6-in. ball-bearing portable electric bench grinder is for use on alternating current only, maintaining a 3600 r.p.m. spindle speed on 60-cycle current and 3000 r.p.m. on 50-cycle current. E.P.R.

"Mathier" block dressing machine. ANON. *Glass*, **7** [4], 148–49 (1930).—The results obtained by grinding glass tank blocks on this machine are infinitely superior to those obtained in any other way. There is a saving in cost over hand dressing. The time required for putting the blocks in position is reduced. But most important, the points between blocks are reduced to a minimum. The machine consists of a motor-driven abrasive wheel. The table upon which the block is dressed is fitted with slides and moves back and forward across the face of the revolving abrasive wheel. The table is adjustable to the size of the block. A suction fan removes the dust. H.W.A.

Micro-accuracy in grinding operations. ANON. *Abrasive Ind.*, **11** [7], 16–19 (1930).—Abrasive processes in making twist drills are of more than usual interest. The methods followed at the plant of The Buckeye Twist Drill Co., are illustrated and described. E.P.R.

REPORT

Abrasives. IV. Artificial abrasives and manufactured abrasive products and their uses. V. L. EARDLEY-WILMOT. Can Dept. Mines, Mines Branch, *Rept.*, No. 699, 144 pp. (1929).—The properties and methods of manufacture of Si carbide and fused Al_2O_3 are discussed. The manufacture and general uses of grinding wheels, selection, shapes, mounting, weight, operating speeds, types of grinding, etc., receive extended consideration. In discussing coated abrasives, the following are described: the manufacture and uses of special papers, flexible grinding and polishing, belts, disks, sanding, buffing, tumbling, etc. For Parts I, II, and III, see *Ceram. Abs.*, **8** [1], 5 (1929). (*C.A.*)

PATENTS

Grinding machine. EDWARD DANNER. U. S. 1,763,647, June 17, 1930. A member having a flat grinding surface, a holder adapted to revolve a plurality of articles about an axis normal to the grinding surface, a presser member moving with the holder and having a flat surface adapted to contact an annular series of articles in the holder, and means to maintain the presser member with its pressing surface parallel with the grinding surface.

Grinding apparatus. HARRY RODEMEYER. U. S. 1,763,820, June 17, 1930. In combination, a grinding element composed of grinding material which has relatively great resistance to wear, another grinding element composed of grinding material which has relatively low resistance to wear but which effects a grinding action relatively great as compared to the grinding action of the first element, means for carrying an article to be ground past the grinding elements in the order named, whereby the first-mentioned element removes burrs or sharp projections from the articles to prevent undue wearing away of the second-named grinding element.

Truing serrated grinding wheels. BENGT M. W. HANSON. U. S. 1,764,043, June 17, 1930. The method of shaping or truing a grinding wheel having a plurality of concentric serrations for cutting threads, etc., which consists in angularly adjusting the wheel so that the serrations are inclined correspondingly to the lead of the thread to be ground, and then truing the serrations in a practical grinding plane.

Grinding machine. WILLIAM L. BRYANT. U. S. 1,765,787, June 24, 1930. A machine comprising a pair of spaced bearings, a sleeved rock shaft journaled in the

bearings, an arm fixed to the rock shaft outwardly of one of the bearings, a rotary shaft journaled in the arm, a tool actuated by the rotary shaft, a counter shaft journaled in the rock shaft, and driving connections between the counter and rotary shafts.

Dressing device for abrasive wheels. JOSEPH MAICKEL. U. S. 1,766,029, June 24, 1930. A dressing device for abrasive wheels comprising a frame, a mandrel journaled on the frame and receiving the wheels to be dressed, a rock shaft journaled on the frame, rock arms splined to the shaft, a base plate carried by the arms and movable therewith toward and from the mandrel, a carriage guided on the plate for movement parallel to the mandrel, a tool holder and tool therein slidable in a plane at right angles to the mandrel, a feed screw journaled on the plate to move the carriage along the plate, a leaf spring fastened to the carriage and pressing the holder and tool toward the mandrel, a guide rod on the carriage to guide the free end of the leaf spring, a coil spring on the guide rod to assist the leaf spring, and a cam on the plate to limit the movement of the holder.

Grinding machine. HENRY H. YERK AND WILLIAM J. BAUMBERGER. U. S. 1,766,161, June 24, 1930. In a grinding machine, in combination, a base, a vertically adjustable bracket disposed at the rear side of the base, the bracket extending over the top of the base and in spaced relation thereto, a work table mounted on the overhanging bracket portion and adjustable transversely of the base, a pair of headstocks mounted on the top of the base and slidable longitudinally thereof and beneath the work table, the headstocks each having a grinding wheel spindle extending outwardly toward the opposed headstock, independent power units carried by each headstock for rotating the spindles on their respective axes, means operated from a common source of power for rotating the spindles in orbital paths about axes eccentric to their own, and means operated from the last-mentioned source of power for reciprocating the headstocks longitudinally of the base.

Centering machine. MARK H. DAMERELL. U. S. 1,766,812, June 24, 1930. A machine for centering crankshafts comprising a frame, a center-marking device mounted thereon and having a center axis along which the device is longitudinally movable to mark the work, a pair of supporting members mounted on the frame, means to move the members simultaneously in a given direction of movement transversely of the axis and to operative position relative to the crankshaft and also to move the members toward and away from each other in a direction transverse to the direction of simultaneous movement, and means on the members effective to engage and center a crankshaft in substantial alignment with the axis of movement of the center-marking device.

Grinding machine. EDWARD F. ROBERTS. U. S. 1,766,839, June 24, 1930. In a machine of the character described, a grinding disk having a grooved driving circumference and parallel grinding faces on either side of the driving circumference.

Insulator bushing. ARTHUR O. AUSTIN. U. S. 1,766,869, June 24, 1930. (1) In a bushing insulator, an elongated tubular dielectric member having an opening therethrough, a conductor extending through the opening, means adjacent the outer end of the opening for limiting the outward movement of the conductor, a nut threaded on the projecting end of the conductor, means for preventing rotation of the conductor in the opening, an imperforate cap threaded on the end of the conductor and having clearance for the nut, the cap making a tight joint with the dielectric member to close the opening, and means for securing a line to the end of the conductor to hold the conductor while the dielectric member is removed therefrom. (2) The combination with a bushing insulator, of a conductor having a threaded end projecting therefrom, and a terminal member threaded on the conductor, the conductor having a slight initial bend in the threaded portion thereof within the portion of the terminal member threaded onto the conductor to insure a tight fit between the conductor and terminal member.

Knife-grinder bearing. ARTHUR W. BEAMAN. U. S. 1,767,272, June 24, 1930.

In a grinding machine, the combination with a hollow support, of a sleeve located therein, ball bearings in the ends of the sleeve, a spindle carried by the inner races of the ball bearings, a grinding wheel on the end of the spindle, a motor shaft at the opposite end of the spindle for driving it, a spring bearing on the inner race of one ball bearing for taking up slack between the two ball bearings and reducing vibration and a dust-excluding compressible washer located between the outer race of the other ball bearing and the grinding wheel.

Abrasive wheel. HAROLD F. SKILLINGS. U. S. 1,767,321, June 24, 1930. In an abrasive wheel, the combination of a body having inner and outer annular walls and an intermediate annular groove; a plurality of partitions connecting the walls to each other at intervals and dividing the groove into a plurality of arcuate chambers, each partition presenting on each side thereof an arc-shaped abutment; a plurality of arcuate, abrasive segments arranged in pairs, one pair in each chamber, each segment having two arc-shaped ends, each resting against one of the arc-shaped abutments; each segment having an arc-shaped surface engaging the outer annular walls, and expansible means between the two adjacent ends of the segments of each pair, each expansible means including two shoes, each presenting an arc-shaped abutment which engages the adjacent arc-shaped end of one of the segments; a wedge between and engaging the shoes, a U-shaped spring secured to the body and having two arms secured to the shoes, respectively, and tending to move them toward each other, and a screw for moving the wedge relatively to the shoes to force them apart.

Interchanger for grinding machine. ALBERT VUILLEUMIER. U. S. 1,767,416, June 24, 1930. In apparatus of the character described, a rotary grinding member having article-receiving grooves, in combination with an interchanger for removing the articles from the grooves and returning them to the grooves in a different order, the interchanger comprising a receptacle having a partition flat at one end and concave at the other to remove the articles from the grooves and cause them to converge and pile up, the bottom of the receptacle being flat, and arranged to receive the articles from the partition and spread them out before returning them to the grooves.

Device for grinding valves, etc. AUSTIN RIEGEL. U. S. 1,767,700, June 24, 1930. A grinding device comprising a tube, a shaft movably located in the tube having a plurality of right hand spiral grooves and a plurality of left hand spiral grooves therein; the left hand spiral grooves intercepting the right hand spiral grooves at points apart from the points where the right hand grooves intercept the left hand spiral grooves, and slidable means carried by the tube and located inside the grooves.

Grinding machine. EDWIN E. SLICK, JR. U. S. 1,767,775, June 24, 1930. In a grinding machine, a movable grinding element, rotatable supports adjacent the grinding element and in spaced relationship to each other and the element, the supports being located above the grinding element, and means to rotate the supports to insure longitudinal feeding movement of an article carried upon and by the supports.

Disk grinding wheel. THOMAS V. THOMPSON. U. S. 1,767,821, June 24, 1930. An abrasive tool comprising a disk wheel, an abrasive disk or ring attached to the face of the wheel, a sectional clamping ring on the periphery of the disk having beveled faces, and means connecting the sectional ring to the wheel including screws having tapered ends complemental to and acting against the bevel faces adjustable for clamping the sectional ring to the disk.

Saw grinder. CHARLES EMMET RANSOM. U. S. 1,768,996, July 1, 1930. In a saw grinder, a slide, a saw carrier thereon, a ratchet on the carrier distinct from a saw mounted on the carrier, an adjustable pawl for the ratchet having a stationary pivot and arranged to engage the ratchet tangentially, an adjustable checking pawl for the ratchet disposed radially thereof and movable therewith and slidable radially thereof when the

ratchet is rotated, and means for reciprocating the slide, the means and pawls coöperating to rotate the ratchet and carrier with alternate movements of the slide.

Saw-grinding and gumming control device. HOWARD CUNNINGHAM AND LOUIS C. SCHWARTZ. U. S. 1,769,016, July 1, 1930. In a saw-grinding and gumming control device, the combination of a broad flat bottom frame plate having pivot ears fixed thereon and also an axle stud fixed thereon distant from the ears, a notched indicator ring to be rotatively guided on the axle stud with an intervening saw hub, a latch head pivoted to the ears and having a coil spring seated therein, and a lever pivoted to the head in contact with the spring and having a projecting finger to be entered separately into the ring notches.

Grinding machine. ONNI S. KOSKINEN. U. S. 1,769,143, July 1, 1930. A grinding machine comprising a grinding member, a guide contact member, a dressing tool for dressing the periphery of the guide contact member, and means for adjusting the position of the tool in coördination to the periphery of the grinding member.

Grinder mechanism. WILLIAM A. TRAUD. U. S. 1,769,870, July 1, 1930. A grinding mechanism for a cutter device comprising a carrier, a rotatable driven abrading element suspended from the carrier and adapted to act upon the device lengthwise thereof, a traveling carriage for supporting the carrier, a latchable, reversible propelling mechanism for the carriage to provide for the alternate travel of the latter in opposite directions, a combined latching and controlling means for the propelling mechanism, and an arm bodily carried by the carriage for intermittently actuating the means to alternately latch and release the mechanism in and from forward and reverse driving position, the arm straddling the means and the means including a pair of spaced, resilient abutments positioned in the path of the arm, the propelling means for the carriage having an element thereof extending into and confined in the carriage.

Grinding machine. CLARENCE C. STEVENS. U. S. 1,770,148, July 8, 1930. In a machine, a rotary spindle, a work holder on the spindle, a hollow sleeve slidable in the spindle, means for conducting cooling fluid to the sleeve, a driving member supported by the spindle, a clutch between the driving member and the spindle, and mechanism for successively disengaging the clutch and sliding the sleeve to cut off the supply of cooling fluid from the sleeve.

Grinding fixture. ANDREW MCANDREW. U. S. 1,770,318, July 8, 1930. A grinding machine including an upper slide, a knee adjustably mounted on the slide and having an upstanding member provided with a ball socket located above its center, an arbor having an integral ball formed intermediate its ends and fitting the socket, and means for locking the ball within the socket and thereby holding the arbor in adjusted position.

Attaching abrasive material to rollers. J. ORMEROD & SONS, LTD. Brit. 328,119, June 12, 1930. A roller for holding abrasive paper for buffing skins, etc., is formed with end walls and bosses, the end walls being also bored at an angle to the axis through small bosses, through which pass a tourniquet device comprising two bars held between turned ends. A head at one end, provided with tommy holes, and a nut at the other end, maintain the tourniquet device in position. The ends of the abrasive material are passed through an undercut groove in the periphery of the roller and inserted through the bars, the tourniquet device being rotated to tighten the material.

Abrasives. FEDERAL PHOSPHORUS CO. Fr. 677,515, June 27, 1929. An abrasive is made by melting bauxite with C and, if desired, with Fe, from which are obtained crystals of Al_2O_3 buried in or surrounded by a sheath solution in acids. The Al_2O_3 is then treated with a mixture of HF and H_2SO_4, HCl or HNO_3. (*C.A.*)

Art and Archeology

Athenian krater. G. M. A. RICHTER. *Bull. Met. Mus. Art*, **25** [4], 96–98 (1930).—A red Athenian krater recently added to the Museum's collection is shown in the Room of Recent Accessions. It is a large and important vase and the painting on it is well preserved, giving a good idea of Greek painting about 46 B.C., the period of the Olympia sculptures. Though the scene on the front of the vase is carefully finished, the one at the back is only begun. Something happened to prevent the painter from completing the work. No doubt he left the details which needed careful attention to be done at another time, but when he was ready to finish it he found that it had already gone into the kiln. This accident sheds new light on the technique of these vases, and clearly shows that Athenian pottery was fired once only, after the whole vase was completed. A.A.A.

Japanese folk art. ROBERT TREAT PAINE, JR. *Bull. Met. Mus. Art.*, **25** [5], 122–24 (1930).—The exhibition of Japanese peasant art represents two phases which came into being with the Tokugawa régime. The paintings are sturdy and humorous and the potteries are heavy in shape and made of coarse material. They show the Japanese love of beauty and of nature. There are three main types: rimmed plates put beneath oil-wick lamps, dinner plates, and wine bottles. Most of these are decorated and come from Seto, although some come from Oribé, Shino, Bizen, and other places. A.A.A.

Exhibition of H. O. Havemeyer collection (ceramics). ALAN R. PRIEST. *Bull. Met. Mus. Art*, **25** [3], 72 (1930).—The special interest of Mr. and Mrs. Havemeyer was in Han pottery and the 17 pieces thus added to the Museum collections present the various glazes in remarkable variety and completeness. There are also 41 examples of the beautiful K'ang Hsi peach blooms. There are other excellent examples of many types of ceramics, especially the Sung and Yüan dynasty Chün yao pieces, the Chien yao bowls, a pilgrim bottle of T'ang pottery with cream colored glaze, and the great sang-de-boeuf vase of the K'ang Hsi period. The Japanese ceramics include examples of the ware of Kyoto, Seto, Takatori, Karatsu, Oribé, Raku, and Satsuma. A.A.A.

Exhibition of H. O. Havemeyer collection (classical art). G. M. A. RICHTER. *Bull. Met. Mus. Art*, **25** [3], 74–75 (1930).—The Classical Department has received as its share of the Havemeyer collection, 19 pieces of glass, 2 glazed terra cotta bowls, and a bronze helmet. The glass is choice and gives an idea of the variety of techniques, shapes, and colors employed by the ancient glassmaker. All are of Roman date except one Greek ointment vase. A Sidonian cup of the 1st Century B.C. or A.D., is an exact duplicate of one loaned to the Museum by J. P. Morgan. The two green glazed bowls are fine specimens of this rare ware, especially interesting because of the lead glaze used at this early period. Chinese pottery of the Han period has similar glazes. A.A.A.

Recent accessions in the classical department. G. M. A. RICHTER. *Bull. Met. Mus. Art*, **25** [5], 136–38 (1930).—The vases and bronzes now shown in the Room of Recent Accessions range in date from the 7th to the 4th Century B.C. The earliest vase is a "proto-Corinthian" alabastron in the form of a human figure. Except for the mantle thrown naturally over the shoulder, the figure is formless and heavy. It symbolizes the Eastern influence which was brought to bear on Greek art during the 7th century by direct contact and through Phoenician trade. An Athenian black-figured kylix of the Kleinmeister type, made by Hischylos is not well preserved except for the incised decorations and the signatures. A red-figured Athenian cup, of the kotyle shape, has a Maenad painted on each side. The pictures are typically Greek and are in the manner of the Brygos painter. The date should be about 480 B.C. An Athenian lekythos has another characteristic Greek rendering, a satyr dancing a wild dance. A vase in the form of a cock probably served as a lamp feeder, the oil being poured out of a small opening in the beak. It is covered with a black glaze except for the comb and

wattles, which are crimson and the circular support at the bottom which is clay colored. A.A.A.

Hellenistic vase. G. M. A. RICHTER. *Bull. Met. Mus. Art*, **25** [6], 150–52 (1930).—New interest was given to late Greek pottery by the introduction of new techniques and colors. Red and black painted vases were gradually discarded and vases were decorated with reliefs instead of painted designs. A rare example in the form of a small pail, evidently a copy of a metal one, is shown in the Room of Recent Accessions. The decoration consists of reliefs and it is covered with black glaze. Such pieces have been identified as Campanian ware, 3rd Century B.C. These pails are interesting as the starting point of the Roman Arretine ware. This example was wheel-thrown and reliefs were applied free-hand. The Arretine ware was carefully reproduced from molds. A.A.A.

European and Near East decorative arts. JOSEPH BRECK. *Bull. Met. Mus. Art*, **25** [3], 64–66 (1930).—The H. O. Havemeyer collection (the bequest of Mrs. Luisine W. Havemeyer) is now on exhibition in Galleries 20 to 25 until Nov., 1930. Among other articles in this invaluable collection is a life-size statue in painted terra cotta of the Virgin and Child, dating from the late 16th or early 17th Centuries. The beautiful lustered earthenware produced in Spain in 15th, 16th, and 17th Centuries is represented by a group of 17 representative specimens. Four 15th Century pieces are very rare; one of them bears the arms of Morelli of Florence. An example of tin-enameled ware decorated in green and manganese, made at Paterna in the 14th Century, is ornamented with coats of arms and star motifs within interlacing bands. There is also an unusual specimen of Venetian glassware of the early Renaissance period, in the form of a small beaker, decorated with gilding and enamel. Another remarkable Venetian piece is a tazza of about 1550 to 1600 with painted and gilded decoration under the glass. The Persian pottery consists of 18 fine specimens: seven 12th Century bowls of rare type; 4 examples of the colorful turquoise blue ware of the 12th or 13th Century; 4 specimens of the white glazed ware with pierced decoration showing Chinese influence from the 12th and 13th Century; and a perfect Gombrūn bowl of the 18th Century with a delicately drawn design. A.A.A.

Late 18th Century English decorative art. PRESTON REMINGTON. *Bull. Met. Mus. Art*, **25** [4], 105–109 (1930).—Recently acquired examples of late 18th Century decorative objects have been added to the exhibition of late 18th Century furniture in Gallery J 11. Included among these is a large cut glass chandelier made about 1787 for Somerford Park, Cheshire. Such a beautiful and fragile example as this is rarely as well preserved. There is also a pair of cut-glass candelabra made very brilliant with strings of crystal pendants. It is a question whether these objects are English or Irish glass as it is hard to tell because of the close relation between the two. A.A.A.

Preparation of Venetian glass and mosaics. H. SCHWARZ. *Glashütte*, **60** [4], 62–63 (1930).—Reprint of an article recounting some of the methods used by the Venetians of the Middle Ages for the production of colored glass. L.T.B.

Römer glass in its original form. HEINRICH HUGO. *Glashütte*, **60** [4], 58–59 (1930).—An outline of some of the characteristics of the glass of the Middle Ages. L.T.B.

New era in stained glass. ANON. *Glass*, **7** [5], 190 (1930); for abstract see *Ceram. Abs.*, **9** [8], 607 (1930). H.W.A.

Synthesizing ultra-marines from various sodium-aluminium-silicates. J. HOFFMANN. *Z. angew. Chem.*, **43** [20], 396–99 (1930).—Ultra-marines cannot be synthesized from natural nepheline. Sodalite and nosean may be partially changed to ultramarines during which process the silicate structure undergoes great changes. The reactions involved in making such changes are given. See also *Ceram. Abs.*, **9** [3], 151 (1930). L.T.B.

Proposed standardization of colors for sanitary ware. ANON. *Commercial Stand. Monthly*, **6** [12], 383 (1930).—There are three kinds of sanitary ware: vitreous china, porcelain (all clay), and enameled iron. The probability of difference in shade arises when one manufacturer supplies the vitreous china lavatory and another supplies the enameled bath. This fact is emphasized in a display of available color samples assembled by the Bur. of Stand., where 104 different shades are shown. A solution of these problems involves much more than the elimination of many existing shades of colors. The following points are necessary in the successful coördination of individual color ranges in vitreous china, enameled sanitary ware, and allied products: The colors must be (1) desirable, (2) economically produced, (3) easily reproduced, and (4) suitable to enameled cast iron, vitreous china, porcelain, wood seats, etc. In a survey of colors used in the production of sanitary ware, green was found to be the most popular color with orchid a close second. Blue was third, while ivory, light brown or buff, and black were about equal in popularity. These six colors have been selected as recommended standard colors for sanitary ware. E.J.V.

Fontainebleau pottery. LUCY CRUMP. *Christian Sci. Mon.*, **22** [179], 9 (1930).—Between the later years of the 16th Century and the early part of the 17th there flourished in the neighborhood of Fontainebleau a pottery which made little figures of many shapes and colors. It belonged to the school of Bernard Palissy, to l'art rustique, with its dishes reproducing all the weeds and beasts of a brook, its jugs twined in high relief with wild roses, its plaques with nymphs and sea-monsters, sea-weeds and shells, often lovely in color, wonderful too in the hard brilliance of its glaze. The potters at Fontainebleau could not rival the old masters, but there is often great charm about the few examples of their work which still survives. In the galleries of the Louvre there are half a dozen of these figures and the Cluny also possesses a few. E.J.V.

Changing colored enamels by action of smoke at low temperatures. HANS ESKA. *Sprechsaal*, **63** [21], 381–84; [22], 401–404; [23], 423–25; [24], 441–44 (1930).—From a succession of preliminary tests, four types of enamels were chosen which differed in their capacity to dissolve color. By mixing 9 ordinary oxides, 36 different oxide mixtures were prepared, making a total of 45 color preparations with the primary oxides. By "oxidized" and "reduced" firing, it was determined what coloring effects these preparations exert on different enamels. It was observed in the copper group that oxide mixtures, in reduced firing, influence the crystallization of the copper particles and, therefore, the formation of red copper in the enamels. The most favorable are: Sb_2O_3, Fe_2O_3, and Cr_2O_3. The appropriate formation of copper crystals depends not only on the kind of firing, but also on the cooling. Lead tin borates with 2 to 3 molecules of SiO_2 are best for lustrous red. If too much quartz is added and constant luster temperature maintained, the enamels remain green. Strongly irisated luster glazing is accomplished by an increase in the thickness and size of copper crystals on the enamel layer. If more than 4% copper oxide is added, or smoking temperatures are too high, the enamels blister. Strongly acid alkali enamels free from lead are adapted for china colors. The size of the kiln, or normal duration of cooling of the kiln, determines the borax addition to the enamels. Tin oxide turns the red color to brown. Opaque enamels are not adapted for china firing. Nickel oxide gave no special results in these investigations. The cobalt mixtures give the greatest variety of blue tones which become luminous with lustering, and darker, with china firing. Uranium greatly changes the action of color in different types of enamels and with different methods of firing. Iron oxide gives vivid coloring structures to weakly acid lead tin enamels. In acid enamels, the iron oxide is more easily soluble and loses this property. In lead tin borax enamels, iron oxide over-rules the strongly coloring chromic oxide. Smoking makes the enamels containing iron darker and more gay in colors. Alkali as well as alkali borax

enamels color iron oxide yellow or yellow-green. The manganese group gives brown to violet enamels. Manganese colors turn brighter and considerably darker with luster firing. With oxidized firing, antimony oxide compensates the coloring produced by up to 3% manganese. As much as 6% antimony oxide dissolves in alkali borax enamels without coloring. But small quantities of Sb_2O_3 cloud these enamels with luster treatment. Antimony has a favorable action on chrome coloring. Chromic oxide makes the enamels containing lead very difficult to fuse and its coloring action is influenced by Fe_2O_3, $UO_2 \cdot 2UO_2$, and Sb_2O_3. Titanium dioxide reacts well with other coloring oxides. Gray silver is obtained by lustering lead enamels with titanium dioxide. This work serves as a preliminary test for further investigations on the difficulty of obtaining china coloring enamels; these will be published later. M.V.K.

Old English glasses. I & II. FRANCIS BUCKLEY. *Glass*, **7** [5], 184–86 (1930).—A description of fine old English glasses from the point of view of the connoisseur is given. H.W.A.

Copper and gold ruby colors. I. ALBERT GRANGER. *Céram. Verrerie*, **49**, 35–39 (1929).—A large number of glass batch compositions are given. G. reviews the theories which have been advanced to account for the ruby color in glasses. **II.** *Ibid*, **49**, 103–108.—G. gives a number of glaze compositions which result in ruby glazes. **III.** *Ibid.*, **49**, 141–42.—The theory of ruby coloration is continued. A.J.M.

Orrefors glass. ILSE E. TROMM-GÖTEBORG. *Glashütte*, **60** [13], 212–13 (1930).—A short history of this famous Swedish glass with an outline of some of the principal decorative motifs. Illustrated. L.T.B.

The Phau family. MICHAEL BIRKENBIHL. *Sprechsaal*, **63** [25], 459–62 (1930).—B. gives a short history of the German family, Phau, who were especially famous in the 17th and 18th Centuries as makers of majolica stoves and other objects of great value and beauty. A description is given of these objects, which are now in the German museums. M.V.K.

New light on Maya art. T. A. JOYCE. *Illus. London News*, **176**, 383 (1930).—The results of last year's discoveries of the British Museum's expedition to British Honduras are now on view at the Museum. The pottery found antedates the Toltec period by centuries. Ten photographs. H.H.S.

Stained glass sundials. J. A. KNOWLES. *Connoisseur*, **85**, 227–31 (1930).—Puritanical prejudice against church windows caused glass-painters of the 17th Century to look in other directions. Coats of arms, sundials, and hanging lamps resulted. Eight sundials illustrated. H.H.S.

Automatic color-matching machine. ANON. *Sci. Supp.*, **71** [1831], 12 (1930).—Colors so similar that they appear identical to the trained eye are distinguished by a machine in which the color is analyzed by a spectroscope, having as its eye a photo-electric cell. A permanent record is made on a moving strip of film showing the percentage of each component color reflected by the sample under test. G.R.S.

Light for decorating. ANON. *Nat. Glass Budget*, **46** [1], 14 (1930).—A new idea in interior decorating, through the medium of colored light that throws countless designs and colors on walls and ceilings at will, is said to have been developed by F. J. Cadenas, illuminating engineer of the General Electric Co. One great advantage it possesses is that it is susceptible to quick changes. The first commercial installation of the system has been made by Cadenas in the ballroom of the St. George Hotel, Brooklyn, N. Y. E.P.R.

American architecture molded in clay. ROBERT SETH LINDSTROM. *Brick Clay Rec.*, **76** [12], 766–67 (1930).—Architecture is the science and art of designing and constructing structures in a style befitting the occupancy and the purpose for which they are erected. Modern architecture is the new American style created within the last

decade in recognition of something characteristic of modern new standards of living, new customs, new arts of hygiene, and applied psychology which distinguish it from classical times. In the recent newly created style of American architecture, the classical orders of architecture have been practically omitted, especially in the skyscraper office buildings, hotel and apartment buildings. Since modern architecture eliminates moldings, cornices, and projections, it leaves the wall surface to depend largely upon the kind of material, texture, and color that will create warmth and at the same time not lose its identity and proportion with relation to the whole building. Such material can be readily found in fired clay products, such as face brick, terra cotta, and tile. Face brick for its durability and utility as part of the wall creates an atmosphere of culture and refinement. In modern architecture, to replace shades and shadows, the wall surfaces must have some varied color combination to offset the bare flat wall surfaces and no material is more suitable, from both an artistic as well as utilitarian standpoint, than face brick. Illustrated. E.J.V.

Art reflected in glass. CHARLES E. VICKERMAN. *Crockery and Glass Jour.*, **108** [4], 18 (1930).—The efforts being made by American designers for glassware to overcome the handicaps of the machine age are discussed. There is a tendency to duplicate the creations of foreign designers. Many manufacturers in America, however, have instructed their artists to develop an expression typical of American life. E.P.R.

Modernistic trend in designs on cement products. GEORGE RICE. *Rock Prod.*, **33** [13], 105–106 (1930).—R. discusses trend of designs on cement tile, flag-stones, garden pottery, flower boxes, etc., including principles of design. W.W.M.

Ceramic ware presented by New York market. ANON. *Crockery and Glass Jour.*, **108** [4], 46–47 (1930).—The Thos. Webb & Sons Co., England, represented by Wm. S. Pitcairn, Inc., is showing some new shapes employing tall stems and fine intaglio cutting. This factory also produces exact copies of famous museum pieces of Jacobite glass. A. H. Heisey & Co. has developed a pattern in flower bowls with handles of various artistic design. New colors are Sahara, a bright hue of yellow desert sand; and Alexandrite, a combination of rose and powder blue resulting in a tint varying from orchid to reddish purple under different lights. The Geo. F. Bassett Co. is showing some distinctive Royal Vinton dinnerware; the designs are hand-painted and consist of floral patterns and border decorations. The Belmont Tumbler Co. has created a new 20-piece green glass tea set. The Edward B. Dickinson Co. is showing a new pattern called Early American Scenes on the Georgian (silverware) shape. Excellent prints reproduced from authentic old etchings and touched with hand-applied enamels depict various historical scenes. A number of other glassware and chinaware manufacturers are listed with descriptions of their recent outstanding creations. E.P.R.

BOOKS AND PAMPHLETS

Working of Glass. (Le travail du verre.) ROUSSET. 196 pp., 141 figs. Published by Ch. Béranger, Liège (Belgium). Price, 30 Belgian francs. Reviewed in *Rev. belge ind. verrières*, **1**, 88 (1930).—Cutting, perforating, blowing of glass, decorations, inscriptions on glass, gilding, silvering, making of household utensils, photographic glasses, electric apparatus, the glass laboratory, and optical glasses are treated. A.J.M.

Coloring and origin of gold ruby and sapphire glasses. B. LANGE. *Repts. Kaiser Wilhelm Inst. Silicate Researches*, Berlin-Dahlem, **3**, 12 pp. (1930).—L. describes his tests and calculations on the coloring and origin of gold ruby sapphire glasses. The results obtained show that metals dissolve in glasses and different salt melts, but this process is neither colloidal nor molecular. The dissolving is chemically conditioned, according to investigations, and leads to the formation of unstable compounds which, when the melt solidifies, disintegrate into the solvent (glass) and free metal, which latter condenses to

the colloidal state. Colloids originate only through condensation or dispersion. A direct colloidal dispersion of the metal occurs in the ruby glasses. Investigations show that the colloidal gold particles in the ruby glass do not originate directly from the metal but by condensation of the gold atoms liberated by disintegration of the above-mentioned compounds. The extinction coefficients show that a small part of the gold exists in a chemically-combined molecular state which takes no part in the coloring. In preparing ruby glasses, it is therefore unnecessary to use large amounts of gold. From the relation between the size of particles and absorption it is seen that the greatest coloring power is obtained from medium sized particles of gold. Very small particles or large particles dilute the color. From the absorption curves given, it is possible to choose the right size of the particles and diminish by about 50% the consumption of gold. The most favorable size of particles also corresponds to the maximum light absorption, about 550 mm. By determining the position of maximum absorption one can ascertain the most favorable dispersion of the gold for the preparation of the ruby glasses. The most favorable grain size also gives the highest luminosity to the color of the glass, as here the absorption curve is most precipitous and shows the sharpest maximum. As this maximum depends on one particle size the presence of other sizes is undesirable; therefore glasses should be fused with particles of only one size. To comply with this requirement the closest possible temperature range should be used in tempering. M.V.K.

Leaflet on latest decorations. ANON. *Crockery and Glass Jour.*, **108** [4], 62 (1930).—A. J. Fondville & Co. have recently issued a leaflet showing many of the newest decorations on the Ambassador, Homestead, and Old Bristol ware. E.P.R.

Art in Australia. (Quarterly.) Edited by S. U. SMITH AND LEON GELLERT. Art in Australia, Ltd., 24 Bond Street, Sydney. Price £2.10 per annum.

Art in New Zealand. (Quarterly.) Edited by H. H. TOMBS AND C. A. MARRIS. H. H. Tombs, Ltd., 22 Wingfield Street, Wellington. Price £1 per annum. H.H.S.

PATENTS

Design for bottle. ALLEN B. THOMAS. U. S. 81,422, June 17, 1930; RUTH D. MAURER AND HERBERT D. JOYCE. U. S. 81,447, June 24, 1930; SPENCER U. BOEHMER. U. S. 81,434, June 24, 1930; IRVING BROMILEY. U. S. 81,520, July 8, 1930.

Design for jar, etc. EMIL FRANK. U. S. 81,439, June 24, 1930.

Design for tumbler. EDWARD E. BARTLETT. U. S. 81,427, June 17, 1930.

Design for goblet, etc. CHARLES C. BEAM. U. S. 81,471, July 1, 1930.

Design for flower bowl, etc. T. CLARENCE HEISEY. U. S. 81,388, June 17, 1930.

Design for illuminating glass bowl. NICHOLAS KOPP. U. S. 81,392, June 17, 1930.

Decorating ceramic goods. "SFINX" SPOJENÉ SMALTOVNY A TOVARNY NA KOVOVÉ ZBOŽÍ AKCIOVÀ SPOLECNOST. Austrian 117,054, Nov. 15, 1929. Porous unfired or unglazed ceramic objects, or objects covered with a dry unfired glaze, are treated with an aqueous solution of a salt forming a colored layer on firing, *e.g.*, a Co salt. The solution is applied in streaks, drops, etc., at such intervals that each streak, etc., spreads into the adjacent ones. The objects are then fired. See also *Ceram. Abs.*, **8** [8], 558 (1929). (*C.A.*)

Cement, Lime, and Plaster

Opportunities for alumina cement manufacture. EDWIN C. ECKEL. *Mfrs. Rec.*, **97** [25], 59 (1930).—To make an alumina cement of high quality and steady grade at a cost which will permit its sale at $2.00 to $3.50 per barrel anywhere in the U.S., the process used must be one which can utilize low-grade bauxite and produce iron or ferrosilicon as a by-product. Two appliances are used: (*a*) a furnace capable of developing melting temperatures, and (*b*) grinding and packing apparatus for the finishing of the

cement, just as in making Portland, natural, or slag cement. In its development the South should have a large share for the bulk of our domestic bauxite supplies occurs in the southern States. E.P.R.

Water permeability of concrete. C. R. PLATZMANN. *Tonind.-Ztg.*, **54** [40], 676–77 (1930).—Methods used since 1867 for the manufacture of a concrete impervious to water are reviewed. M.V.K.

Water impermeability of concrete. C. R. PLATZMANN. *Tonind.-Ztg.*, **54** [43], 718–20 (1930).—P. describes two methods for manufacturing a water-tight mortar directly, instead of using the so-called "chemical" methods, most of which act only mechanically by filling the pores. The first concerns the composition and the kind of flux materials used. Here the use of trass and similar products as pozzuolana (Santorine earth), diatomaceous earth (moler earth), phonolite, and Si-substance are shown to have a favorable influence on the impermeability of concrete and they also act as binding agents. Trass increases the elasticity. The second method discussed is the use of "hard concrete." This is a composition with an extremely hard and resistant flux material such as iron borings of a definite size, corundum, silicon carbide, and many materials containing quartz. As binding agent, the early high solid, high-quality cements and their improved varieties are used. "Hard concrete" is usually applied in layers up to 20 mm. thick, and covers ordinary concrete. It is quite impermeable to water and has the added advantages of greater solidity and resistance. M.V.K.

Permeability of concrete to water. C. R. PLATZMANN. *Tonind.-Ztg.*, **54** [45], 748–49 (1930).—Methods used since 1882 for rendering concrete impervious to water by painting or coating the surface are discussed. The use of tar, asphalt, or other bituminous materials, begun in 1904 is especially recommended as a protection for concrete and reënforced concrete against driving rain, dampness, or chemicals. Recent experiments with metallic salt solutions of fluosilicic acid have shown the latter to be excellent for closing the pores of mortar by combining chemically with the surface. There is no decrease in the solidity with this method, but on the contrary, an increase in the hardness of the surface. M.V.K.

Influence of damp-cold weathering on early high resistances of high-quality concrete with different additions of water and cement. ORTHOUS. *Beton Eisen*, No. 6, p. 113 (1930); *Tonind.-Ztg.*, **54** [43], 730 (1930).—The resistance value for Portland cement determined in the laboratory according to standard tests, at a considerably higher temperature (about 18 to 20°C) are misleading in practical construction. The only exception is alumina cement, which is insensitive to damp-cold weathering and even to the action of frost up to about −10°C. In this case, the early high resistance of concrete at the place of construction is similar to that obtained by laboratory tests at 18 to 20°C. This was established by tests on 20 concrete cubes. The necessity of tests with other building materials, cement and pyrite sand, is emphasized. M.V.K.

Portland cement and pozzuolana. A. POULSEN. *Tonind.-Ztg.*, **54** [10], 161–62 (1930); *Rock Prod.*, **33** [11], 91 (1930).—Of all the different kinds of pozzuolana known, moler earth is the best and is used in Denmark for the preparation of Portland cement. It consists of $^2/_3$ to $^3/_4$ silicic acid with other hydraulic factors. The soluble alkaline part of raw moler amounts to more than 50% and increases with vitrification up to 66%; while in trass (another kind of pozzuolana) the soluble part amounts to only 20 to 30%. Raw moler was used first, but since 1924, fired moler has been used, which gives a fine red color to cement, and a higher solidity than gray moler. The latter is more plastic, however, and is used for the preparation of cast concrete, while the former is used for buildings and mosaic work. Both are also used as a covering for cement roof tile as they prevent weathering. Tables of different compositions of concrete with moler and trass, and their properties, are given. M.V.K.

Testing plastic mortar. HAEGERMANN. *Tonind.-Ztg.*, **54** [18], 296–99 (1930); *Zement*, pp. 167–74 (1930); *Rock Prod.*, **33** [11], 91 (1930).—H. reviews different methods of testing plastic mortar and points out their advantages and disadvantages. He emphasizes the necessity of testing the flexibility of plastic mortar instead of testing its tensile strength. M.V.K.

Slaked lime and concrete. RICHARD GRÜN. *Tonind.-Ztg.*, **54** [44], 738 (1930).—The influence of lime additions was investigated on (1) plasticity, (2) solidity, and (3) water-tightness of concrete. The results show that the solidity is not influenced unfavorably by small additions of lime, while plasticity and water-tightness are increased. M.V.K.

Research develops new knowledge of cement aggregates and concrete. ANON. *Rock Prod.*, **33** [14], 101–105 (1930).—Reports of the committees on cement, concrete aggregates, gypsum, lime, and plaster are given. Some information is presented on rate of hydration of clinker, steam curing for resistance to sulphate waters, and workability of concrete. W.W.M.

Practical and technical notes on the heterogeneity of limestones for lime and cements. JOSEPH DEFORGE. *Rev. mat. constr. trav. pub.*, No. 247, pp. 137–41; No. 248, pp. 178–82 (1930). A.J.M.

New comparisons between tensile, compressive, and flexure strengths of cements. R. FERET. *Rev. mat. constr. trav. pub.*, No. 247, pp. 127–33 (1930).—Three ordinary Portland cements, "iron Portland," aluminous cement, blast-furnace cement, and pozzuolana (gaize) cement were used in the experiments. The comparisons between the strengths of the different cements are shown by graphs. A.J.M.

Behavior of concrete at high temperatures. RICHARD GRÜN AND HUGO BECKMANN. *Stahl Eisen*, **50** [24], 840–41 (1930); for abstract see *Ceram. Abs.*, **9** [8], 618 (1930). M.V.K.

Pozzuolana cement for use in sea water. G. BAIRE. *Rev. mat. constr. trav. pub.*, No. 248, pp. 168–70 (1930).—A special type of French pozzuolana cement called "gaize cement" is satisfactory. The properties are given. A.J.M.

Enamel applied cold. SOC. ANON. DES USINES DE LA BASSE MEUSE AND OTTO RUPPEL. *Chem. Abs.*, **24** [2], 516 (1930); *Emaillewaren-Ind.*, **7** [22], 173 (1930).—An enamel which can be applied cold on all materials consists of 3 parts Portland cement, a part slag cement, 10 to 15% pigment, and 0.1 to 0.5% of a heavy metallic salt of an organic acid or the corresponding free acid. M.V.K.

Thermal study of the manufacture of cement. H. LEFART. *Rev. mat. constr. trav. pub.*, No. 248, pp. 171–76 (1930).—A complete heat balance, with calculations, is given for a rotary kiln. A.J.M.

Influence of fineness of grinding and chemical composition on quantity of mixing water for cement. HANS KÜHL. *Rev. mat. constr. trav. pub.*, No. 248, pp. 184–90 (1930); for abstract see *Ceram. Abs.*, **9** [3], 154 (1930). A.J.M.

Researches of sand on the place of building. M. BARASCUD. *Rev. mat. constr. trav. pub.*, No. 246, p. 111 (1930); *Tonind.-Ztg.*, **54** [49], 821 (1930).—B. suggests determining the moisture of the sand from the variability of the specific gravity with the increase in water content. As the specific gravity of dry sand fluctuates very little, it need be determined only once. Every day, the specific gravity of the wet sand should be determined and the moisture content calculated. M.V.K.

Relationship between limestone, quicklime, and slaked lime. MAX PULFRICH. *Tonind.-Ztg.*, **54** [44], 737–38 (1930).—P. shows the relationship between the chemical and physical structure of limestone and its behavior at firing, and the properties of the slaked and fired product. M.V.K.

Influence of sands on cement mortars. P. P. BUDNIKOFF. *Zement*, **18** [49],

1410–11 (1929); *Rock Prod.*, **33** [13], 94 (1930).—The test results indicate that the various kinds of sand have differing influences upon the cements. W.W.M.

Chemistry of cements of high qualities. HANS KÜHL. *Tonind.-Ztg.*, **54** [39], 659–63 (1930).—The most important ingredients of Portland cement clinker are alite and celite and therefore the raw paste must be so prepared, and the lime content so proportioned that the greatest possible quantity of alite and celite are formed by firing. The process of clinkering of cements is important and the use of fluxes facilitating this process is good. Cements which were not too finely ground were found best, when clinkered. If the raw powder is too fine, the clinker obtained is of a low quality. A coarser grain size increases the lime content in the clinker and gives it a better quality. The length of firing and velocity of cooling are also of great significance. Investigations showed that quick cooling increases the hardening capacity of clinker and slow cooling prevents crystallization. The same phenomena occurs in the case of ferro Portland cement and blast-furnace cement. The finer a cement clinker is ground, the shorter is its setting time; thus, a slow-setting cement can be changed into a quick-setting cement by finer grinding. Some admixtures beside gypsum have a great influence on the beginning of setting. Small additions of lithium, sodium, potassium, aluminium, ammonium, calcium, strontium, barium, cadmium, and iron as chloride increase the solidity of cements. Manganese, tin, and especially zinc and copper lower its solidity. Lead ruins it. In general, metals with a low atomic weight are advantageous and the metals of high atomic weight are injurious. The action of anions is less known, but with the addition of 2% calcium bromide the resistance to pressure of cement was raised from 58 to 238 kg. in one day. As a result of his study of catalyzers, K. is sure that great progress will be made in this field, but because of the difficulty of the problem, it will be a long time before the effect of catalyzers and their general use in cement industry is clearly understood. M.V.K.

Temperature and corrosive salt solutions. E. PROBST AND K. E. DORSCH. *Pit and Quarry*, **19** [2], 117 (1929); for abstract see *Ceram. Abs.*, **8** [12], 863 (1929). E.P.R.

Study of action of trass in lime-cement mortars. P. MECKE. *Pit and Quarry*, **20** [5], 73 (1930); *Rock Prod.*, **33** [13], 95 (1930); for abstract see *Ceram. Abs.*, **9** [7], 503 (1930). E.P.R.

Electrical researches on the setting and hardening of quick-setting cements. ANON. *Sci. Repts. Tôhôku Imp. Univ.* [Japan], **17** [7]; *Sprechsaal*, **63** [13], 233 (1930).—The researches of Josomatru Shimizu on measurements of the electrical resistance and the setting and hardening of the so-called quick-setting cements are reported by the Japanese Tôhôku Univ. In the conductivity-time curves of the alumina cements two breaks were determined, one of which corresponds to the compounds of calcium aluminates with water and the second to calcium-alumina silicates or calcium silicates. In the compounds of calcium-alumina silicates or calcium silicates with water in the supercement of the Portland type only one break of the curve was determined, from which it can be concluded that the fired slag (clinker) of Portland cement does not contain calcium aluminate. The samples were of Portland cement of high quality "Dickerhoff Double" and the English quick-setting cement "Ferrocrete," while examples of alumina cements were the French "ciment fondu" and the American "Atlas Lumnite." M.V.K.

Theory of blowing of hydraulic agent. HENRI LAFUMA. *Tonind.-Ztg.*, **54** [35], 602 (1930); for abstract see *Ceram. Abs.*, **9** [7], 503 (1930). M.V.K.

Reduction of heat loss from wet-process kilns. HANS ENGEL. *Pit and Quarry*, **20** [4], 79 (1930); for abstract see *Ceram. Abs.*, **9** [7], 505 (1930). E.P.R.

Iron vs. alumina. ALTON J. BLANK. *Rock Prod.*, **33** [12], 82–83 (1930).—B. reviews and discusses Katsuzo Koyanagi's article. For abstract see *Ceram. Abs.*, **9** [8], 617 (1930). W.W.M.

Fineness modulus held superior to sieve test. A. HUMMEL. *Zement*, **19** [4], 355–64 (1930); *Pit and Quarry*, **20** [6], 77 (1930).—A complete method of interpreting the screen analysis is Abrams' fineness modulus reckoned from the sum of the percentages retained on a series of sieves in which each successive sieve has a mesh width double that of the foregoing. All aggregates with the same fineness modulus require the same amount of mixing water and yield the same concrete strength, whereas an endless number of gradings may give the same fineness modulus. This method also makes possible the interpretation of sieve analyses from aggregates in which certain intermediate sizes are lacking, allowing the calculations of method of improving the grading to reach the desired fineness modulus. E.P.R.

Experiment on hydrates of tricalcium aluminate. ANON. *Zement*, **19** [4], 394–99 (1930); *Pit and Quarry*, **20** [6], 77 (1930).—In a paper presented at the last meeting of the Verein Deutscher Portland-Cement-Fabrikanten, Wilhelm Eitel discusses the work of Thorvaldson of the Univ. of Saskatchewan on the hydrates of tricalcium aluminate, emphasizing particularly his finding that ordinary cements, through treatment with steam under pressure at about 150 to 175°C, become, to a large degree, immune against the action of sulphate waters. He reports further on the production of pure, well-defined hydrates and on their properties; the higher hydrates with 12, 10.5, and 8 molecules of water are stable only at low temperatures and at 25° yield spontaneously to the regular form of the hexahydrate. E.P.R.

Fineness and strength of cement. I. S. NAGAI. *Pit and Quarry*, **18** [13], 113 (1929); for abstract see *Ceram. Abs.*, **8** [1], 18 (1929). E.P.R.

Strength formula for cement. SHOICHIRO NAGAI. *Jour. Soc. Chem. Ind.* [Japan], **31**, 1159–66 (1928); *Pit and Quarry*, **18** [13], 113 (1929).—Unwin's rational formula $y = a + b\,(x - 1)^n$, in which a is the strength at one week, y is the strength at x weeks, b is a constant of cement, and n is 1, $^1/_2$, $^1/_3$, etc., is not applicable to the rapid-hardening Portland cements. The parabolic equation between strength and curing age was modified to a linear equation: $S = A + B\,(\log d)$; S is the strength at d days, and A and B are constants for each cement. By applying many results of tests at many curing ages and calculating by the method of least squares, constants A and B were obtained for tensile and compressive strengths of each cement. A linear relation between B and activity index or silica modulus were observed. $B = (S - A)/\log d$; activity index = $SiO_2 \cdot Al_2O_3$; silica modulus = $SiO_2 \cdot Al_2O_3 + Fe_2O_3$. E.P.R.

Hydraulic modulus for slags. S. GIERTZ-HEDSTROM. *Svensk Kem. Tidskr.*, **41**, 119–24; *Pit and Quarry*, **18** [13], 113 (1929).—A new modulus is proposed for slags which are hydraulic, calculated from the amounts of the components of the slag which are attacked and unaffected by water, respectively. If the slag is to be hydraulic the ratio between the two groups must be greater than 1.

$\dfrac{(CaO + MgO + CaS + SO_3 + \ldots\ldots)}{(SiO_2 + Al_2O_3 + FeO + MnO + \ldots\ldots)} > 1$. It is claimed that this formula affords a better measure of the hydraulic value of the slag than the one usually employed, *i.e.*, $\dfrac{(CaO + MgO)}{(SiO_2 + Al_2O_3)} > 1$. E.P.R.

Manufacture of hydraulic lime. R. BLIN. *Le Ciment*, July (1929); *Pit and Quarry*, **18** [13], 112 (1929).—The products obtained in calcining limestone fall into several classes depending upon the content of silica or clay in the raw material. If it is pure limestone, so-called "fat lime" will be obtained after slaking. If it contains free silica, it is "lean." A content of clay or other combined silica results in a hydraulic lime. The first two grades harden only in air after drying; their use is limited and their tensile strength is negligible. Hydraulic limes harden under water, whether fresh or salt. A dense limestone calcines less easily than a porous one and must be crushed to very

small pieces. The clinkering of the limestone influences in marked degree the value of the hydraulic lime formed. In general, the raw material must be calcined longer, the greater the clay content. The decomposition temperature varies from 1550 to 1750°F. E.P.R.

Tests for proportioning raw materials for Portland cement. ANON. *Cement and Cement Mfg.; Pit and Quarry,* **18** [13], 66–68 (1929).—The two methods in general use for keeping a constant check on the accuracy of the mixing of raw materials are (1) by the calcimeter and (2) by titration. There are many calcimeters in use. Faija's compensated apparatus, and Scheibler's calcimeter, both used for the volumetric estimation of calcium carbonate by the measurement of carbon-dioxide gas evolved are described. By the titration test the calcium carbonate is decomposed by a measured quantity of standard nitric or hydrochloric acid, and the excess of acid determined by titration with standard alkali. This test necessitates the careful preparation and standardization of solutions by qualified chemists. The method is based on the chemical action of a given quantity of acid of known strength on a given weight of carbonate of lime, the excess of acid being found by titration with standard alkali. The solutions required for the titration test are normal hydrochloric acid and seminormal sodium hydroxide. E.P.R.

Simple determination of water requirement of poured concrete. A. GUTTMAN. *Zement,* **17,** 1794–95 (1928); *Pit and Quarry,* **19** [2], 117 (1929).—The consistency required for practical purposes is determined with a piece of chute mounted on pipe frame so that its angle of inclination may be adjusted to any desired degree. A charge of 3 liters of the wet batch to be tested is emptied into the top of the 15-in. chute and is caught below to be measured. When the material adhering to the chute is 0.7 to 1.0 liter, the batch has desirable consistency and H_2O content. E.P.R.

Ternary system lime-carbon dioxide-silica; an investigation of hardening of lime mortar. G. F. HÜTTIG AND EMIL ROSENKRANZ. *Pit and Quarry,* **19** [2], 117 (1929).—Hardening of lime mortar occurs in two stages: drying and carbonization. The first may take only a few hours. Analyses of mortars up to 2500 yrs. old show that carbonization is not complete even in that time. The presence of MgO results in less absorption of CO_2. Liberation of CO_2 from $CaCO_3$ by active forms of SiO_2 occurred at 873° but not at room temperature. Quartz did not show appreciable action on $CaCO_3$ at 800°. X-ray examination showed $CaCO_3$ but no $CaSiO_3$ in mortars 580 to 970 yrs. old. Tables of analyses of 5 mortars aged 430 to 970 yrs. are given. Talc did not form $MgCO_3$ at 80-lb. CO_2 pressure in 6 hrs. at 200 to 400°. E.P.R.

Compound controls setting time of cement. ANON. *Eng. News-Rec.,* **104,** 951 (1930).—Remarkable properties are claimed for Sika a waterproofing compound designed for use with Portland cement concrete or mortar. Properties claimed are (1) complete control of setting time, (2) greater adhesion to roughened surfaces, (3) greater strength at all ages, (4) greater density, (5) less shrinkage, and (6) complete resistance to the action of fresh or salt water acids or oils. The material works by means of a chemical reaction with the cement, this reaction making the lime particles insoluble. W.L.

Forty-year old concrete in Crystal Springs dam still water tight. F. R. MCMILLAN AND M. B. LAGAARD. *Eng. News-Rec.,* **104** [19], 766 (1930).—Its excellent condition after forty years of service is attributed to the use of a dry mix and thorough tamping which resulted in the complete filling of the space between the aggregate particles with a cement paste of low water-cement ratio. Additional factors of importance were the use of clean, sound aggregates and careful provisions for thorough curing. W.L.

Precautions recommended for concrete in alkali soils. ANON. *Eng. News-Rec.,* **104** [18], 725 (1930).—For concrete of highest resistance to sulphate action use (1) a

Portland cement which has a high natural resistance, (2) durable, well-graded aggregates, (3) a rich mix, (4) as little mixing water as possible, preferably with a slump not greater than 3 to 5 in., (5) for structures cast in place, cure under moist conditions as long as possible, and allow to dry in air before allowing alkali ground water to come into contact, (6) precast structural members should be cured in steam above 100°C, (7) where thorough drainage cannot be obtained place bituminous membrane waterproofing continuously below the ground level, (8) for any given cement and aggregate the concrete of highest impermeability will probably be most resistant, and generally the concrete of highest strength will be least permeable. W.L.

Testing cement. C. R. PLATZMANN. *Cement and Cement Mfg.*, **3** [5], 673 (1930).—The need of new methods of testing cement and the importance of attaining uniformity of tests by the specified methods are discussed. Specific gravity tests may be dispensed with. The importance of fineness tests by present sieve methods has greatly diminished as finer grinding has reduced the amount of residue retained on the sieves. If precise definition and standardized determinations of setting time, soundness, and strength are satisfactorily specified, all other measurements will be unnecessary or of minor importance. Rigid definition of initial set is necessary. A regulation regarding final set could possibly be dispensed with, though it appears to have some value for the control of the hardening process. The most valuable soundness test is the 28-day test. Accelerated tests for soundness do not offer complete security against later expansion. For strength tests both tensile and compressive strengths have their value and the mechanical preparation of test specimens is advocated for the sake of uniformity. The use of plastic mortars has many advantages for testing purposes and should be investigated further. The greatest difficulty with the plastic mortars, at the present time, lies in the agreement regarding a standard sand of mixed grain size. W.L.

Entropy of Portland cement. G. MARTIN. *Cement and Cement Mfg.*, **3** [5], 678 (1930).—It is not only the quantity of heat applied which counts, but even more the thermal pressure (temperature) at which the heat is delivered to the substance. This may be expressed by introducing the conception of entropy. The change of entropy of a substance is measured by the quantity of heat which passes into the substance divided by the absolute temperature at which it passes in. The magnitude of the entropy changes which occur at different stages of cement clinker formation are important for correct kiln design. A table is given showing the change of entropy of the solid materials which occur in making one pound of clinker. W.L.

Preliminary studies and control of concrete on Port of New York Authority work. A. W. MUNSELL. *Eng. News-Rec.*, **104** [22], 902 (1930).—M. describes preliminary tests and methods of proportioning used to obtain high quality concrete. The concrete was designed for 2500 lbs. at 28 days. The compressive strength at two years was 3690 lbs. W.L.

Influence of fineness of Portland cement on its properties. P. FILOSSOFOV. *Pit and Quarry*, **20** [6], 46–48 (1930); for abstract see *Ceram. Abs.*, **9** [7], 501 (1930). E.P.R.

Comparison of methods for feeding rotary cement kilns. E. SCHIRM. *Rock Prod.*, **33** [14], 88–89 (1930); for abstract see *Ceram. Abs.*, **9** [4], 261 (1930). W.W.M.

Development of limestone products. ANON. *Rock Prod.*, **33** [14], 49–58 (1930).—An illustrated description is given of the operations of H. E. Millard, Annville, Pa., including the production of calcined lime, high calcium cement rock, crushed aggregate, and a special pulverized high-calcium lime product. The conquering of a serious water problem is described. W.W.M.

False setting time of cement. F. WHITWORTH. *Cement and Cement Mfg.*, **3** [4], 567 (1930).—W. believes the false set to be due to a partial dehydration of the gypsum.

This dehydrated gypsum sets to build up a slight internal structure soon after gaging. The cements possessing this false set have nevertheless sufficient SO_3 in solution to retard the setting of the cement proper. Tensile strength of such a cement shows that there is no difference between a cement gaged quickly and left to harden, and a cement regaged after the false set has been allowed to develop thoroughly. W.L.

Gypsum and gypsum products manufacture. I. S. G. MCANALLY. *Rock Prod.*, **33** [14], 70–73 (1930).—M. gives the composition and properties of, and impurities found in gypsum. He gives time and temperature data on decomposition and describes the preparation and calcination of the raw material, including a discussion of "boil-overs" and kettle temperatures. W.W.M.

Raw mix control in manufacture of Portland cement. ARTHUR J. POOL. *Rock Prod.*, **33** [14], 77–79 (1930).—P. determined (1) loss on ignition, (2) calcium oxide, (3) calcium carbonate, and (4) calcium oxide in calcined raw mix in 36 samples, and determined the calcium oxide in clinker from the same materials. Calcium oxide in the uncalcined raw materials was found to bear the most constant ratio to the CaO in the clinker, while the ignition loss ratio deviated most. The former was concluded to be the best control method in point of accuracy but the $CaCO_3$ determination is more rapid and simple and nearly as accurate as the CaO method. W.W.M.

Overcoming heat losses in cement manufacture. GEOFFREY MARTIN. *Rock Prod.*, **33** [14], 59–67 (1930).—M. presents recent research work done on cement kiln design with special reference to dust, spray, or flotation kilns. He discusses the temperature and amount of heat required for Portland cement formation and the connection between flame temperature and clinker output. The chief causes of kiln inefficiency are radiation losses, the greatest clinker loss being due to internal radiation caused by the large volume of empty space within the kiln. The vertical shaft kiln is more efficient but has a smaller output than the rotary kiln. Internal radiation loss in rotary kilns may be decreased by baffling, but the baffles must stand abrasion at white heat and they also hamper the draft. Davis (Brit. 307,763, see *Ceram. Abs.*, **8** [7], 484 (1929)) tried dust as a means of curtailing internal radiation, but due to faulty feeding of raw material his fuel consumption was high. Girouard (Brit. 260,684) overcame Davis' difficulty by sinking a shaft through the limestone in the quarry, lining it with refractory material and letting the raw material fall through the shaft. The burners were near the bottom of the shaft and the clinker was removed through an adit. The chief difficulty was the loss of dust carried upward by the hot gases. This was overcome by Martin (Brit. 276,066, see *Ceram. Abs.*, **7** [10], 665 (1928)) who increased the cross-section of the upper part of the shaft, decreasing the gas velocity. M. states that this "flotation" kiln gives better mixing of raw material, and less interruption of production because of its simplicity, there being no moving parts. A large-scale experimental flotation kiln, 150 ft. deep and having an area of 800 sq. ft. at the top was constructed at Asheham, England, and shows promising results. Illustrated. W.W.M.

Use of fuel in manufacture of Portland cement. H. P. REID. *Jour. Amer. Soc. Mech. Eng.* [Advance paper], pp. 7–10 (Oct. 1929); *Fuels and Fur.*, **7** [11], 1769–70 (1929).—R. discusses the heat required for drying and clinkering cement and producing power, fuel selection, wet and dry manufacturing processes, operation of rotary kiln, and power generation from waste heat. W.W.M.

Determining solubility of gypsum. WALLACE C. RIDDELL. *Rock Prod.*, **33** [13], 76 (1930).—Experimental work was done on gypsum treated in a Raymond kiln mill which pulverizes the material at an elevated temperature thus removing part of the water of crystallization. As the material reaches the desired fineness it is blown out of the pulverizer by a fan. Solubilities of some raw and calcined gypsums were determined with the following results:

	Grams $CaSO_4$ per 100 cc. H_2O at 75°F
Av. for gypsum, $CaSO_4 \cdot 2H_2O$	0.22
Av. for calcined gypsum, approx. $CaSO_4 \cdot {}^1/_2H_2O$	0.74
Av. for soluble anhydrite, $CaSO_4$	0.77
Av. for natural anhydrite, $CaSO_4$	0.13

Samples of gypsum calcined at temperatures from 300 to 1300°F for one hour showed an increase in solubility up to the 500°F sample which had lost all combined water, and then a decrease in solubility with increase in calcining temperature. The greatest decrease in solubility was between 600°F and 700°F. The addition of NaCl was found to increase solubility slightly. The setting time of calcined gypsum varies with the solubility. R. suggests the Raymond kiln mill as a means of preparing gypsum as a cement retarder as the product is more soluble. This increases the effect on the cement. W.W.M.

Hydration of calcined gypsum. W. C. HANSEN. *Ind. Eng. Chem.*, **22** [6], 611–13 (1930).—A study was made to determine why soluble materials when added to calcined gypsum-water pastes either accelerate or retard the setting of the pastes. From a study of time-temperature curves obtained from the hydrations of calcined gypsum in various solutions, it appears that the controlling factor in the setting is the rate at which precipitation takes place from the paste. A study of the rate at which gypsum precipitated from carefully mixed solutions of calcium nitrate and ammonium sulphate to which has been added other salts shows that foreign salts markedly affect the rate at which gypsum precipitates from its supersaturated solution. This effect of foreign materials upon the rate of precipitation of gypsum from its supersaturated solution appears to explain the ability of foreign materials to accelerate or retard the setting of calcined gypsum pastes. R.G.M.

California's largest cement mill. ANON. *Rock Prod.*, **33** [13], 41–48 (1930).—An illustrated description of the improvements at the Santa Cruz Portland Cement Co. plant. W.W.M.

New wet-process cement plant in Texas. TERRELL BARTLETT. *Eng. News-Rec.*, **104** [22], 889 (1930).—The structural and manufacturing features of a recently completed wet-process cement mill are given. B. discusses selection of site, quarry, layout of plant, plant construction, grinding equipment, and process control. W.L.

BOOKS AND BOOKLETS

Agents Affecting Concrete. (Einflüsse auf Beton.) F. HUNDESHAGEN AND OTTO GRAF. Published by A. Kleinogel, Berlin, 1930. 3rd ed. 37.50 M. *Z. angew. Chem.*, **43** [20], 408 (1930).—Among the agents which are treated in this book are first of all the cement, aggregate, particle size, water added, and method of placing the concrete. In the second part are treated all physical and chemical agents which may affect the concrete during hardening. Among such agents are blasting and earthquakes, lightning, and the action of X-rays. Mussels and other aquatic animals occupy their portion of the book. The chemical agents are given the largest part of the publication. L.T.B.

Basic Principles of Concrete Making. FRANKLIN R. MCMILLAN. McGraw-Hill Publishing Co., Ltd., London. Price 10s net. Reviewed in *Engineering*, **129** [3358], 677 (1930). A.A.

Constitution of Mortar and Concrete. (Der Aufbau des Mortels und des Betons.) OTTO GRAF. 3rd ed. Berlin, 1930, 16 M. *Z. angew. Chem.*, **43** [20], 408 (1930).—Not only does this book contain information on the strength of mortar and concrete but also on other important properties such as bending strength, water penetrability, volume constancy, and resistance to wear. G. is thoroughly familiar with the subject and gives

a clear picture of the dependence of the properties of mortar and concrete on the nature of the cement, aggregate, water added, and also the thoroughness of preparation. The book is well illustrated with curves and photographs. L.T.B.

Gypsum Investigation. P. P. BUDNIKOFF. Published by Acad. Sci., U.S.S.R., Leningrad, 1930. 180 pp. R4.50.—B. describes (1) the characteristics of gypsum, (2) its deposits, (3) its chemical and physical properties, (4) kinds of gypsum, (5) semihydrate, (6) setting of the semihydrate, (7) soluble and insoluble anhydrate, (8) estric gypsum and the improvement of its properties, and (9) obtaining sulphur from gypsum. The second part of the work contains the description and results of different experiments made by B. from 1918 to 1929, some of which have already been published in different papers. M.V.K.

Cement for acid-handling purposes. ANON. *Brass World*, **26** [5], 128 (1930).—A cement which provides a bonding material for use in places where hot or cold acid gases are retained, requiring acid-proof properties, has been developed by the Quigley Furnace Specialties Co. This material is fully described in a booklet recently issued by the company and available upon request to them. E.P.R.

PATENTS

Manufacture of a cement or plaster from gypsum. FRANCIS MULLIGAN. U. S. 1,766,448, June 24, 1930. A process for the manufacture of a cement or plaster from gypsum, in one heating operation, comprising stacking crude gypsum together with coal in a closed kiln and in about the proportion by weight of one part of coal to eight parts of gypsum, subjecting the gypsum to slow calcination by burning the coal so that in the process of calcination the products of combustion are caused to permeate the gypsum and thoroughly act thereon for such a period of time as will bring the gypsum to a stage when efflorescence begins to appear, and then cooling the calcined mass.

Plastic compositions. I. G. FARBENINDUSTRIE AKT.-GES. Brit. 328,538, June 25, 1930. A cement and mortar powder containing the binding agent in solid form is made by mixing readily soluble hydrated silicates, *e.g.*, water-glass powder, with substances which react with alkali, *e.g.*, silicon or sodium silico-fluoride. *E.g.*, 600 g. of powdered commercial sodium water glass which still contains 17 to 25% water are mixed with 170 g. sodium silico-fluoride. To this mixture is then added $2^1/_2$ times its weight of sand and made into a paste with 9 to 10% water. The product is acid-proof, but not waterproof. A small addition of aluminous cement renders it waterproof also. Other fillers including lead glass are mentioned. See also *Ceram. Abs.*, **7** [7], 432 (1928).

Enamels

Acid-resisting white dry-process cast-iron enamels. A. I. ANDREWS. *Jour. Amer. Ceram. Soc.*, **13** [8], 509–21 (1930); for abstract see *Ceram. Abs.*, **9** [3], 161 (1930).

Progress report on effect of furnace gases on quality of enamels. A. I. ANDREWS AND E. A. HERTZELL. *Jour. Amer. Ceram. Soc.*, **13** [8], 522–29 (1930); for abstract see *Ceram. Abs.*, **9** [3], 161 (1930).

Impurities in commercial feldspars often overlooked by enamelers. JAMES R. CRANDALL. *Jour. Amer. Ceram. Soc.*, **13** [8], 530–31 (1930); for abstract see *Ceram. Abs.*, **9** [3], 161 (1930).

Cast iron for enameling purposes. ANON. Bur. Stand., *Tech. News Bull.*, No. 156, p. 34 (1930).—Since the publication of the report on this investigation (see *Ceram. Abs.*, **9** [2], 85 (1930)) samples of iron which gave serious trouble in regular production have been sent in from three plants and have been studied with a view of determining the source of their blistering tendency. The defects of the various irons are described

and the results obtained by applying successfully the published findings of the investigation are given. R.A.H.

Outline of application of enamels to cast iron. J. H. D. BRADSHAW. *Foundry Trade Jour.*, **42** [708], 193–94 (1930).—The definition of a vitreous enamel by Claudius Popelin is as follows: "Enamel is a glass fusible at a low temperature, and usually compounded of a mixture of borates and silicates. This mixture, originally colorless, combines with the greatest ease with all, or almost all, metallic oxides, under the influence of a pyrotechnic operation, thereby acquiring various bright and somber colors, according to the nature of the oxide, which the enameler can vary at will and place a comprehensive palette at his disposal." The enameling process consists of three distinct stages, *i.e.*, (1) preparation of casting, (2) preparation of enamel, and (3) application of enamel to castings. The castings must be thoroughly cleaned and examined for surface defects. Sand-holes and blow-holes in the casting must be filled with a refractory material with just sufficient clay and fluxing material to bind the whole together at the firing temperature. Dry powdered quartz 4 parts, dry powdered enameling clay 2 parts, and soft waste enamel one part, with sufficient water to give a plastic mass is an excellent filling. Sulphur stopping must be avoided. The preparation of the enamel demands the most scrupulous care and cleanliness in all operations. The ideal enamel should be fairly thin, have a high gloss, possess good covering power, and offer great resistance to attack by acid and dilute alkaline solutions. Its most essential feature is that it must have a coefficient of expansion approaching that of the iron or crazing and chipping will take place. The enamel is produced by carefully weighing and mixing the raw materials, screening, and fusing in a "frit" furnace. The "frit" furnace is of the reverberatory type. Coal firing makes too much dust and ashes which may contaminate the enamel and should be avoided. Rotating furnaces are coming into use. The fritting temperature is 900 to 1600°C and the time required for a 400-lb. charge is about 2 hrs. The composition determines the temperature for fritting and the molten enamel is quenched in clean cool water held in tanks. The frit is dried and ground in stone or pebble mills. The suitable amount of tin oxide for white enamels or suitable oxides for other colors is added. For wet enamels 6 to 10% clay is added and a suitable "vehicle," Epsom salts ($MgSO_4$) and well-calcined magnesia (MgO), is used. The vehicle is necessary to give the enamel that "creamy" consistency and to hold the glass in suspension. For the dusting process no water or clay is added and the metallic oxides for opacifying and coloring are fused in the frit. There are three types of vitreous enamels, *i.e.*, opaque, semi-opaque, and transparent. The opaque type is used on baths, sinks, hollow-ware, etc. The semi-opaque is used as a protective coating against rust and is known as "gray glass enamel." The transparent type is used to produce the imitation majolica on cast-iron fire grates, stoves, and ornamental work. The transparent enamels contain 40 to 60% PbO and have a low fusing point. The enamel is applied to cast iron by the "dry" or dusting process or the "wet" or swill process. The dusting process consists of heating the cleaned castings to redness, withdrawing them, and dusting the finely-ground dry enamel by means of a sieve on the castings until the necessary thickness is obtained. The castings are replaced in the furnace until the enamel has run down to form a smooth coat. Majolica effects are produced by dusting a transparent enamel powder of the desired color upon a red-hot casting that has already been coated with an opaque white enamel. Sometimes a body enamel is applied to the casting before the final enamel. This consists of about 60 to 70% silica, 10% alumina, and 10 to 20% borax and is used wet. The wet process may be divided into two classes (*a*) the Continental process and (*b*) the American process. In the Continental process the casting is coated with a fairly thick coat of refractory enamel, containing about 80% SiO_2, dried, and heated to a dull red, then withdrawn, cooled, and the coating moistened with clean water. The

final enamel is applied to this porous coating either by "swilling" or spraying. When dry the casting is heated until the enamel has formed a smooth surface. In the American method, a first coat and a finishing coat are applied wet. The first coat is fusible and free from metallic oxides. After firing the enamel has a glossy surface and when cool the second coat is applied and fired. The operation of dusting, spraying, drying, and firing may be repeated until the finish desired is obtained. The enameled casting now has a glossy surface which is durable and artistic and will defy varying temperature, dirt, rust, and water. H.W.A.

Production of iron castings for enameling. J. H. D. BRADSHAW. *Foundry Trade Jour.*, **42** [699], 32–34 (1930).—The castings are generally thin. A good impression of the mold is required to give a surface suitable for enameling. The composition of the metal is as important as the correct composition of the enamel for they go hand in hand. If the composition of the metal varies, the coefficient of expansion will vary and crazing or chipping of the enamel may result. The ideal iron will contain: total carbon 3.5–3.7; silicon 2.50–3.0; manganese 0.30–0.50; sulphur 0.060–0.090; and phosphorus 1.40–1.80%. Such an iron will have a cubical expansion of about 0.000033/°C. In German and American practice, irons contain less phosphorus and more manganese than in the usual English practice. Excess phosphorus causes embrittling, as also does manganese. If the silicon falls below 2.0%, embrittling will be observed. The use of steel scrap or cast-iron scrap should be avoided. As large numbers of castings are made from each pattern, they are made of steel. The pattern should be of uniform thickness to prevent chilling and hard areas. There must be no sharp edges or points in the casting as enamel will not adhere to them. The molds are made in green sand. A good sand will contain 90% SiO_2 and 10% Al_2O_3. Sand containing over 0.5% lime must be rejected. Facing sand must be carefully prepared as an excess of coal dust, if it is left in the casting, often causes blistering of the enamel. A good facing sand is made up of 9 parts of old floor sand, 5 parts of new sand, and 1 part of coal dust, well mixed and screened. Soapstone powder has been used to prevent the burning of the sand and to produce smooth castings without the use of coal dust. Plumbago or graphite is sometimes used. The surface to be enameled should be in the bottom of the mold so that any slag or dirt will be at the back of the casting. The gates or runners should be on the edges of the casting and not on the face. The metal should be poured quickly and the castings removed from the molds as soon as possible to prevent small rust spots known as sand spots which retard adherence of the enamel. Sand spots may be removed by a good annealing, scraping the spots with a stone or file, and then carefully sandblasting. All fines and gates, lumps, scabs, or other surface defects must be removed by the emery wheel. The enameling surface should not be polished as enamel will not adhere to a smooth surface. The castings must be clean and a slightly etched surface is ideal for enameling. Sandblasting is generally most effective and economical. Metallic or hardened steel balls or shot should not be used as abrasives. Acid pickling has not as yet been successful as cast iron is porous and absorbs large quantities of acid, which on heating will vaporize and cause blistering. Graphite also is deposited on the surface as the acid dissolves some of the iron. The graphite during the enameling process, will form carbon dioxide and cause blistering. H.W.A.

Graphite in cast iron. A. ALLISON. *Foundry Trade Jour.*, **42** [720], 417–18 (1930).—The physical properties of cast iron are largely governed by the quantity and form of the graphite it contains. The microscope reveals three forms of graphite, (1) flakes slightly curved, (2) small curly flakes arranged in floral patterns, and (3) nodules or spots. A nuclei theory is given in connection with the desirable curly and nodular forms. The theory is that in the smelting the coarse graphite produced in the pig iron by smelting at high temperatures does not completely dissolve but remains as an emulsion

in the molten metal, and on cooling forms nuclei for the formation of coarse graphite flakes. The normal cast iron on freezing, immediately after changing from liquid to solid, is white iron, and the carbon is ejected from solid solution according to conditions of composition and speed of cooling. The thickness of the graphite flakes is about $^1/_{1000}$ in. and it is difficult to conceive why so small particles should not become completely dissolved as they are so closely associated with the metal. A series of experiments were made to verify the nuclei theory. The evidence was negative. A new theory, however, is proposed. In cast iron the graphite flakes are frequently entangled with manganese sulphide crystals. It is suggested that the precipitation of the graphite is produced by the sulphide crystals acting as nuclei. In Swedish pig iron the sulphur is the lowest and the number of sulphide crystals is small and widely scattered and hence the frequency of small and curly graphite in the iron, indicating supercooling for lack of precipitants. Experimental verification of the above theory would be almost impossible on even a laboratory scale. The article is illustrated with micrographs. H.W.A.

Over-annealed steel recognized through X-ray spectrometry. H. A. SCHWARTZ. *The Foundry*, **58** [9], 197–99 (1930).—The science of X-ray spectrometry permits definite conclusions to be reached on annealing. The Laue method with modifications is used. Micrographs accompany the X-ray spectrograms of several specimens of steel. The results obtained are explained. H.W.A.

Importance of clay in enamel. ANON. *Ceram. Ind.*, **15** [1], 67 (1930).—The functions of clay in enamel are (1) as an agent to hold the frit and mill additions in suspension; (2) as a refractory; (3) as an adhesive to increase the strength of the dried enamel; (4) as the agent used in imparting the viscosity necessary to adherence to the shape to be enameled; (5) as an opacifier. The amount, fineness, and purity of the added clay are important. Clay added in lumps usually varies in moisture and so different percentages of dry clay are being added. Addition of clay slip to the mill would be desirable, but since most enameling plants have no facilities for making clay slip, powdered clay is used as the next best form of addition. W.W.M.

Use of re-milled enamel saves costs. ANON. *Ceram. Ind.*, **15** [1], 68 (1930).—A saving can be made by re-milling the residue from the spraying booth, with a small amount of clay slip or powdered clay. Re-milling should be for a very short time to prevent production of extremely fine enamel. The re-milled enamel may be used by itself for a first coat or in case of single coat ware it could be blended with new enamel. W.W.M.

Pickling in the enamel industry. ANON. *Glashütte*, **60** [4], 59–62 (1930).—Outline of various chemical methods for pickling the forms prior to enameling. L.T.B.

Protection of metals. J. DUBOIS. *Brit. Chem. Abs.*, March 7, 1930; *Emaillewaren-Ind.*, **7** [22], 173 (1930).—D. found a method to protect metal surfaces from the action of air or gases containing sulphur, by scattering a powdered mixture of sand, clay, feldspar, borax, and sodium hydroxide on the red hot surface. This mixture melts at glow heat and forms a smooth enamel. M.V.K.

Air bubbles in decorative enamels. WILHELM LINKE. *Emaillewaren-Ind.*, **7** [22], 169–70 (1930).—L. discusses the appearance of air bubbles in decoration enamels: during firing the pores are filled up with a jelly-like mass of soda and hydrochloric acid which leads to the formation of bubbles. To prevent this, an addition of 5 to 8% of finest quartz powder to the frit is advised. M.V.K.

Enamels free from cryolite. VIELHABER. *Emaillewaren-Ind.*, **7** [22], 170–71 (1930).—V. discusses the preparation of cheap enamels free from cryolite and describes investigations. He prepares enamels with additions of glass rich in boric acid (0.75 enamel + 0.25 glass) and containing 3.5% fluoride. This enamel has a white appearance and is durable. Neither are small quantities of cryolite (up to 2%) injurious in

powder enamels. Cooking utensils may contain up to 3.5%, other ware up to 16% cryolite. M.V.K.

Opacifying agents. ANON. *Amer. Enameler*, **3** [4] 5 (1930).—From time to time new opacifying agents are brought to light. Most of these stay in favor only for short periods of time, and are soon discarded. There are two kinds of opacifying agents: (1) those used in compounding of the raw batch before smelting, (2) those used as a mill addition, and seldom in the smelting of the frit. The enameler must make certain to procure the proper opacifier. J.N.U.,JR.

Troubles encountered in some English enameling plants. J. H. GRAY, JR. *Amer. Enameler*, **3** [4], 3 (1930).—General conditions and some of the more common troubles encountered while servicing a large number of English vitreous enameling plants are reviewed. J.N.U.,JR.

Rumbling vs. sandblasting. J. A. SMEETON. *Foundry Trade Jour.*, **42** [711], 257 (1930).—It is claimed that rumbling reduces the casting strains which is not possible in sandblasting. For small castings, efficient rumbling done in a well-designed machine is just as economical and in other ways superior to the slower and more commodious sandblasting machines. A new type rumbling machine is described. The sandblast is clumsy, dirty, and more dangerous than rumbling. The large variety of castings, however, ejected from the tumbling barrels requires hand-sorting. The larger and heavier castings, nevertheless, must be cleaned with a water jet and steel shot or grit. H.W.A.

Rust spot on iron castings. NEVILLE DEANE. *Foundry Trade Jour.*, **42** [703], 110 (1930).—The rust spots were distributed over castings used for enameling purposes both inside and outside and developed during the night following casting. The rust spots would develop again after sandblasting if another day's delay followed before enameling. After extensive tests it was finally determined that the water used to dampen the mold sand was impure, containing calcium chloride. The calcium chloride fused on the iron and in moist air the very deliquescent chloride absorbed water and rusted the iron. Sandblasting did not remove the fused spots. H.W.A.

Elasticity and fatigue strength of cast iron. ANON. *Foundry Trade Jour.*, **42** [702], 90–91 (1930).—The fatigue strength of cast iron was determined by applying rotating bending stresses to the test bars. The elasticity had to be known for the determination of the stresses in the surface fibers. It was found that the modulus of elasticity is influenced by the number and form of the graphite flakes. The investigators show how stresses are distributed in a bar which is subjected to rotating bending. The damping effect of some cast irons, *i.e.*, the capability of converting by friction part of the energy applied to them into heat, was examined by determining the hysteresis curves under various static loads. It was found that the damping effect was greater with an iron rich in graphite than with a high-test iron. A distinct relationship between the fatigue strength and tensile strength could not be established. The highest fatigue strengths were found in irons showing a pearlitic matrix and a fine distribution of the graphite; whereas the lowest strengths were associated with a ferritic matrix. H.W.A.

Enamelers Guild develops new ground coat. ANON. *Ceram. Ind.*, **14** [6], 685 (1930).—A new ground-coat enamel that eliminates burned-off edges, fishscale, and copperheads, and withstands much abuse is announced by the Enamelers Guild. It is said to save one spraying and one firing operation. W.W.M.

Developments in vitreous porcelain enameling industry. R. C. HARSON. *Ind. Finishing*, **6** [5], 72 (1930). (*C.A.*)

Preparation of luminous enamel. A. ANDRÉ. *Emaillewaren-Ind.*, **7** [22], 175 (1930); for abstract see *Ceram. Abs.*, **9** [6], 417 (1930). M.V.K.

Modern German methods of manufacturing cast-iron baths and other sanitary ware.

ANON. *Foundry Trade Jour.*, **42** [709], 210–13 (1930).—The most modern methods and processes used in German plants are described in detail. H.W.A.

Modern, small enameling plant. ANON. *Ceram. Ind.*, **15** [1], 64–66 (1930).—A description of the plant and process of the enameling department of the Junger's Stove and Range Co., Grafton, Wis., is given. W.W.M.

BOOK

Principles of Metallurgy. JOHN L. BRAY. Ginn and Co., London. Price 25s net. Reviewed in *Engineering*, **129** [3355], 561 (1930). A.A.

Glass

Formation of seeds and bubbles in glass pots. WILLI M. COHN. *Jour. Amer. Ceram. Soc.*, **13** [8], 555–60 (1930).—Observations on glass pots in plants, experiments on laboratory pots, and theoretical considerations point to the fact that the occurrence of seeds and bubbles may be prevented by the introduction of porous pot walls or by the introduction of porous fireclay rods or similar objects into the melt. The porosity of the walls must be maintained throughout the entire duration of the melting process.

Coloring agents in glass. I. L. M. ANGUS-BUTTERWORTH. *Glass*, **7** [1], 8–10 (1930).—A brief history of ancient Egyptian colored glasses is given. The idea of the early Egyptians was to produce something that would emulate precious stones rather than to produce transparent glass. A later use of colored glasses was in cathedral windows. Colored glasses, whether for use in cathedral windows, or for any other purpose, are of two main kinds: (1) pot metal, of the same color throughout, and (2) flashed or coated metal, where a thin coating of colored glass is superimposed upon a foundation of clear glass. In the second type, the saving in the cost of the quantity of colored glass is offset by the difficulty of welding of two glasses of different natures. Analyses of the colored glasses in the cathedral at Reims and St. Remi are given. Opal glasses fall into two main classes: (1) those in which the opacifying agent dissolves, leaving the glass transparent while molten, but causing it to become opaque on cooling; (2) those in which the opacifier never wholly dissolves, but remains evenly and finely distributed throughout the molten metal. The source of opal color may be either excess of silica, excess of some metallic oxide such as alumina, tin, or antimony, or the presence of fluorides or phosphates. Typical batch weights for six different opal glasses are given. Alexander L. Duval d'Adrian has recently sought to show that, by using the complex fluorides of silica, boron, tin, zirconium, and titanium with the fluorides of the alkaline earths and heavy metals, and adding various mixtures of these to an ordinary glass batch, more satisfactory results are obtained than with simple fluorides. The increasing use of opal glass for a wide variety of purposes is notable. Some of the more common uses are given. The original source of ruby color in glass is gold. On account of the high cost of production, gold rubies are made more rarely now. Almost equally good colors are obtained from copper and selenium. Cuprous oxide, melted under reducing conditions, nitrates and arsenic being absent, gives an excellent ruby. Lead, if added, should be in the form of litharge and not as red lead. The color is caused by the deposition of exceedingly minute particles of copper throughout the glass. A scarlet tinge is obtained by adding one part of ferrous oxide to every four parts of cuprous oxide used. Reheating a copper ruby causes the particles to aggregate giving a copper aventurine glass. Many other colors, browns, yellows, greens, blues, purples, and black are obtained with copper by the proper control of conditions. Ruby glasses are used probably more frequently for casing purposes. Selenium commercial red glasses contain colloidal selenium as pigment. The color is difficult to retain because, if great care is not taken, the selenium has

a strong tendency to volatilize. The color often appears only on reheating in the leer or annealing oven. Several batch compositions for selenium and copper red glasses and ruby glasses are given. Today gold ruby is made from a soft lead batch containing an excess of antimony and arsenic. The gold is added in the form of a solution of gold chloride. Uranium oxide with an oxidizing agent gives colors varying from a light henna to a deep ruby. In the case of gold one part of gold to 50,000 parts of glass will give a bright red color. II. *Ibid.*, **7** [2], 52–54 (1930).—Blue glasses are obtained with cobalt and copper, cobalt being the more commonly used. Cobalt is so powerful that a very small quantity is needed to produce a rich coloration. An oxidizing atmosphere should be maintained during the melting of copper blue glasses. The cobalt enters into solution while the copper is in colloidal suspension. It is claimed that copper colors lime-soda and lime-potash glasses blue, but the color changes to green as the concentration is increased. Glasses rich in silica tend to give green colors with copper, and a high lime content is favorable to red copper glasses. Gold is capable of producing a blue color in glass. A gold-containing glass cooled quickly tends to be colorless, reheating develops a red color, and if kept too long at a high temperature a blue color can be observed. Green glasses are produced with iron, copper, and chromium as the coloring agents. Iron, added as ferric oxide or as hydrated ferrous sulphate, gives various shades of green depending on the amount used. Cupric oxide under oxidizing conditions gives green glasses. The batch compositions for opaque Celadon green and an Iris green is given. Chromium is used as Cr_2O_3, $K_2Cr_2O_7$, and K_2CrO_4 to make green glasses. The green color is increased under reducing conditions. A common defect in chrome green glasses is the presence of black specks caused by undissolved chromium oxide, lack of purity of chromium used, or low furnace temperature. In tank furnaces, the chromium is usually added as a chromate salt and in pot furnaces as a bichromate or chromium oxide. The oxide is more liable to give black specks than the bichromate. Chrome-aventurines are produced with certain concentrations of the coloring oxides. Varying shades of yellow are produced by means of carbon, sulphur, cadmium, uranium, and silver. Carbon is added as coke, graphite, anthracite, etc. For some time it was thought that the sulphate-containing impurities in the carbon were the true source of the color. Now Springer states that the yellow color may be due to carbon in a colloidal condition. When glass colored by carbon was treated with hydrofluoric acid a black deposit of insoluble carbon was obtained. Amber glasses are made by using a mixture of sulphur and charcoal as coloring agents and melting under a reducing atmosphere. Glasses can also be colored yellow with cadmium sulphide. Finely divided colloidal silver gives a fine yellow stained glass favored in church windows. Grays are produced by combinations of (*a*) cobalt, nickel, and uranium oxides or (*b*) magnesium, iron, and copper oxides. Typical batch mixtures are given. Recently bismuth was used to color glass, giving a color varying from gray to brown. Purples are obtained by exposing manganese glasses to the solar rays of short wave-length and to the β- and γ-rays of radium. Blacks are obtained by high concentrations of manganese and a little cobalt or antimony and reheating. Modern uses for colored glasses are almost countless. Some of the more common uses are given. H.W.A.

Study of the chemical reactions in melting of potassium borosilicate glass. M. A. BESBORODOV AND L. M. SILBERFARB. *Jour. Soc. Glass Tech.*, **14** [53], 39–51 (1930).—The results of the tests were as follows: (1) The reaction between the components of a batch of potassium borosilicate sets in at a temperature below 500° below the melting point of any of the components. Considering the absence of potash in the combinations insoluble in water obtained below 700°, we must conclude that at low temperatures potash forms soluble borates or silicates. (2) The curve of insolubility in water of the melts rises steeply between 700° and 900°. The most rapid formation of insoluble

potassium borosilicate takes place within this temperature interval, and a large part of it is formed at this time. (3) As the analyses of the insoluble residue show, no insoluble potassium borosilicates are formed until 700° is reached. The participation of potash in the formation of insoluble potassium borosilicates relates to temperatures above 700°. (4) The participation of boric oxide in the formation of insoluble borosilicates is observed at 500°, but below 700° it is quite insignificant in amount. It becomes important when potassium carbonate also occurs in the reaction, *i.e.*, at temperatures above 700°. Considering the low percentage of boric oxide in the insoluble residue at 500°, 600°, and 700°, where its relation to silica is nearly constant, it may be concluded that the introduction of potassium carbonate into the reaction within the temperature interval between 700° and 800° facilitates the entrance into the reaction of boric oxide, and its percentage in the insoluble residue increases rapidly during this period (from 1.6 to 8.37%). (5) The formation of double insoluble systems begins below 700°. (6) The formation of triple insoluble systems $p\mathrm{K_2O}$, $m\mathrm{B_2O_3}$, $n\mathrm{SiO_2}$ begins at temperatures above 700°, but below 800°. (7) Examining at various temperatures the molecular composition of the insoluble potassium borosilicates newly formed we see that with a rise in the temperature (*a*) the content of silica decreases; (*b*) the content of potassium oxide increases at temperatures below 900°, but decreases with a further rise in the temperature; (*c*) the content of boric oxide increases uninterruptedly with rise of temperature. Thus, the higher the temperature of the melt, the more insoluble combinations are formed in it. (8) The comparison of the data concerning the chemistry of the melting process of soda borosilicate glass with those of potassium borosilicate glass shows that on the whole the reaction of the formation of silicates proceeds similarly in both cases.

G.R.S.

Thermal expansion of glass. I. General form of expansion curve. W. E. S. TURNER AND F. WINKS. *Jour. Soc. Glass Tech.*, **14** [53], 84–109 (1930).—Two main lines of investigation are (1) the relation between thermal expansion and the kind and content of oxides present and (2) to gain a clearer concept of the nature of glass. The glasses, in the form of rods, were studied over the range of temperature from the ordinary temperature to the softening point in each case. In the apparatus employed, the specimens were maintained in a horizontal position by a spring adjusted to apply a standard force equivalent to 100 g. acting on a surface of approximately 5 mm. diameter. The results showed that (1) whereas it is possible to obtain concordant results between the measurements on two separate specimens of glass over most of the range from the ordinary temperature upward, the expansion curves invariably diverge somewhat below the upper annealing temperature. (2) Homogeneous and inhomogeneous samples of glasses have been found to give duplicate results in close agreement. (3) Between the ordinary temperature and a point called the divergence temperature, the thermal expansion curve for a strained specimen of glass lies above that of the well-annealed specimen; from the divergence temperature upward it lies below. Some badly strained glasses (particularly those containing $\mathrm{B_2O_3}$) may undergo a contraction greater than the reversible thermal expansion over part of the range above the divergence temperature. (4) Heat treatment appears to affect $\mathrm{B_2O_3}$-containing glasses and probably glasses containing mixed alkali oxides rather more than soda-lime-silica or potash-lead oxide-silica glasses, even when the latter are grossly inhomogeneous. (5) Two cases have been observed of glasses in which the critical or transformation point is not evident. In one of these cases the transformation appeared after heat treatment. (6) The critical range, or the temperature between the transformation and the softening points, hitherto regarded as about 40 to 50°, has been found in different glasses to vary from 0° to as much as 115°. (7) In none of the measurements was the critical or transformation point found to be sharp, as stated by Klemm and Berger; nor have any sharp change

points within the critical range been discovered. (8) The thermal expansion may undergo continuous and great change within the critical range: as much as six- to seven-fold with some B_2O_3 containing glasses. (9) The critical point and annealing temperature were found to be practically constant in repeated experiments on the same glass. (10) Transition temperatures occur in the thermal expansion of most glasses in the temperature range between the ordinary temperature and the critical point. The number of such transition points has been found, in different glasses, to vary from 0 to 4. In silicate glasses, these transition points are closely the same throughout. Borate glasses containing no silica also show transition points, but at different temperatures. (11) Analogies between glasses and solids are discussed, and it is suggested that our knowledge now warrants the recognition of a vitreous state and it is unnecessary to endeavor to classify a glass among either liquids or solids. **II. Glasses of the series sodium metasilicate.** *Ibid.*, 110–26 (1930).—Pure sodium carbonate and specially selected quartz were melted in platinum vessels, the mixture being first sintered in a large silica crucible from 700 to 800°. Fifteen glasses containing from 51.15 to 91.60% SiO_2 were prepared in a high degree of purity and homogeneity and the thermal expansions determined from the ordinary temperature up to the softening point. The following results were obtained: (1) A lower critical point, C_t, or transformation temperature appears to be lacking in the glass containing 51.15% SiO_2, which is therefore abnormal. In the other glasses, the value of C_t at first rises with increase of SiO_2 content and then remains relatively constant. (2) The upper critical point or annealing temperature, A_t, rises steadily, although somewhat irregularly with silica content until 85% SiO_2 is present, and from that point with much greater rapidity. (3) The thermal expansion curves for glasses containing 88% and more of SiO_2 are extraordinary in showing little or no evidence of bend-over even when taken to 650°, despite the fact that, optically determined, the annealing temperature lies well below this temperature. The rule of Twyman does not seem to apply to these glasses of very high silica content. (4) The number of transition points in the expansion curve between 0° and C_t varies with the composition of the glass, ranging from three in the glass with 55.42% SiO_2 present, two at about 80%, one from that point to 85%, and none in the glasses richer in SiO_2. (5) Wide variation in thermal expansion occurs with about 40% change in SiO_2 content. For the temperature range 0 to 130°, the linear expansion varies between 1765 and 430 $\times 10^{-8}$ for the glasses with 51.15 and 91.6% SiO_2, respectively. (6) The new measurements made over the temperature range 0 to 130°, substantially confirm those of English and Turner but differ profoundly from those of Samsoen. No evidence was found for deducing the formation of eutectics or of compounds which the latter supposes. (7) The relationship between chemical composition and thermal expansion for all ranges of temperature below the critical point, C_t, is strictly linear between 60 and 85% SiO_2 and probably linear, at slightly different inclination, between 85 and 100% SiO_2. From a point corresponding with 87.5% SiO_2 the different curves unite. G.R.S.

Prolonged effect on digitalis purpurea of exposure under ultra-violet transmitting glass. ADELIA MCCREA. *Science*, **71** [1839], 346 (1930).—Digitalis purpurea seedlings were grown under an ultra-violet transmitting glass, with controls under ordinary glass in an adjacent section of the same greenhouse. The treated plants proved considerably superior to their controls in the content of the characteristic active principle, the increase of potency being 51.5%. Modern methods of glassmaking have increased the efficiency of greenhouse propagation. G.R.S.

Choice of annealing schedule for commercial glassware. J. B. MURGATROYD. *Jour. Soc. Glass Tech.*, **14** [53], 3–16 (1930).—There are two principal conditions governing the type of schedule to be chosen: (1) compositions of the glass, and (2) amount of strain permissible in it after annealing. A discussion is given of the method of choosing

an annealing schedule in works practice for glass not used in optical work, special attention being given to economical considerations. Annealing is considered as the removal of strain by viscous yielding and may be carried out in a few minutes at a temperature at which the ware will not go out of shape. M. shows that the allowable cooling rates from a high annealing temperature will be quite large enough to make that the more economical schedule. The annealing temperature is only dependent upon the viscosity of the glass, and is defined as that temperature at which at least 95% of the strain is removed in three minutes. During the cooling of glass which is hot enough to be of a very low viscosity the removal of strain will be practically instantaneous, but there will be a temperature gradient from the center portions to the outer walls. Any increase in this temperature gradient will cause strain which will not be removed by viscous movement so that when the glass comes into temperature equilibrium this strain will be relieved. Temperature equilibrium will cause new strain, as the glass was strain-free only when the temperature gradient existed across it. The annealing range is defined as that range of temperature below which the annealing temperature extending to the point where only 1% of existing strain is removed in three minutes. Allowance must be made for the unevenness of temperatures in the leer. Calculations are given to illustrate the order of gradients permissible under two possible conditions, (1) where the annealing temperature is higher than the critical point where the expansion coefficient increases, and (2) where the annealing temperature is at or below this critical point. See also *Ceram. Abs.*, **9** [7], 519 (1930). G.R.S.

Principles of the annealing of window glass. II. F. TAFFIN. *Rev. belge ind. verrières*, **1**, 72–73 (1930).—Although all stress may be removed from glass at the annealing temperature, new stresses are acquired during cooling. The interior stress is tensile and is expressed by the equation $F = 416\,a^2h$ (window glass), where F is the stress in kg./cm.^{2}, a is $^1/_2$ the thickness of the sheet of glass in cms., and h is the rate of cooling in °C per min. From the equation the following points may be deduced: (1) the internal stresses due to cooling a sheet of glass are proportional to the rate of cooling; (2) the internal stresses acquired by 2 sheets of glass cooled at the same rate are proportional to the squares of the thicknesses of the sheets. Practically, a sheet 2 mm. in thickness may be cooled 9 times as rapidly as one 6 mm. thick. Glasses that are annealed at a temperature below that of rapid annealing require a longer time for removal of stress but the glass may be cooled more rapidly. For glasses no thicker than 2 cm. nothing is gained by annealing at a temperature below that of rapid annealing. The limiting value of tensile strength for bottles is 15 kg./cm.^{2}, while for optical glasses 2 kg. is taken. Cooling may be very rapid from the lower annealing temperature (temperature of tempering) to room temperature. Care should be taken in insulating leers or annealing ovens since the proper amount of heat must be permitted to escape. For Part I see *Ceram. Abs.*, **9**[8], 623 (1930). A.J.M.

Flexible production with superheater glass tank. ANON. *Ceram. Ind.*, **15** [1], 61–63 (1930).—A description is given of a recuperative type glass-melting tank with a patented air superheater. Among the advantages over the regenerative tank claimed for this type of tank are (1) low fuel consumption ($^1/_3$ ton of coal per ton of glass on small tank), (2) less space requirement per ton of output, (3) elimination of expensive flues, reversing valves, and reversal losses, (4) constant, uniform, and higher flame temperature, (5) lower repair cost, (6) requirement of less glass in tank per ton of output, (7) mechanical draft, (8) production of more brilliant glass, (9) adaptability to natural gas, fuel oil or raw producer gas fuel without expensive auxiliary apparatus, (10) elimination of batch dust in heat exchanged by slag pocket, (11) uniform capacity rating during life of flux blocks, (12) possibility of quick color changes in product, (13) less oxidation of materials due to low excess air, and (14) requirement of smaller buildings. The tank is fully protected by U. S. and foreign patents. W.W.M.

Laminated glass as biggest contribution to safety. THOMAS B. HENRY. *Glass Ind.*, **11** [7], 152 (1930).—The use of nonscatterable glass in windshields and windows of motor cars is the biggest single contribution to safety in recent years. It has been found by bus line operators that their installations of nonscatterable glass had paid for themselves during the first six months of operation resulting in a saving in accident claims. The demand for nonscatterable glass has resulted in revolutionary changes in glassmaking methods. One manufacturer alone is said to have spent approximately $14,000,000 for changes in equipment designed to produce the thin glass sheets used in making the laminated type of glass for use in automobiles. E.J.V.

Arsenic as an ingredient in glass. WILLIAM BLOCH AND D. E. SHARP. *Glass Ind.*, **11** [7], 153–56 (1930).—Arsenic is used in the glass industry as a refining agent, a decolorizer, and an opacifier. Its most valuable function is as a decolorizer. Arsenic operates chemically in glasses as an oxidizing agent at high temperatures. Its expense prohibits its general use as an opacifier. Arsenic should never be used in glass that is to be reworked for it causes the glass to blacken in the flame. Foodstuffs may be preserved in arsenic-bearing glass without becoming contaminated with arsenic. Illustrated. E.J.V.

"Lustraglass:" new product. ANON. *Glass Ind.*, **11** [7], 171–72 (1930).—Lustraglass, a new ultra-violet ray glass to sell at ordinary window glass prices, is made by an improved process, vertically flat drawn. It is unusually clear, white, and perfectly flat, being almost entirely free from the greenish color characteristic of the usual window glass. Data on tests of the glass show the following transmission figures:

Wave-length	Transmission	Thickness
334 μ	71%	0.090 in. (2.28 mm.)
313 μ	18%	0.090 in. (2.28 mm.)

The further claim is made that the glass transmits a substantial amount of these vital shorter rays of sunlight even at 310 μ. Illustrated. E.J.V.

Distinction of colored glasses by three-color theory. VON GÖLER. *Sprechsaal*, **63** [21], 385–87; [22], 405–408; [23], 426–27 (1930); *Licht u. Lampe* [Berlin], **19** [5], 295–300 (1930).—The work treats the regular relationship between the spectral composition of a radiation and the resulting impression of light on the eye. A short introduction of the Young-Heimholtz theory of color sensations is given, which shows how, on the basis of this theory, color impression produced by radiation can be determined and distinguished. The valuation of signal glasses is treated, particularly with regard to luminosity and color of the transmitted radiation. M.V.K.

New glasses. C. GAHLEN. *Diamant*, **51** [26], 508–509 (1929).—New colored glasses are discussed. The coloring effects of the rare-earth oxides are described, having been introduced into some of the new glasses by German investigators. Some of the effects obtained have led Paul Kirchberger to designate some of these glasses as "chameleon glasses." In the thinnest layers the glasses exhibited iridescence and appeared in all colors except orange and yellow, the color varying with the thickness. No composition of glasses are given. These glasses could be used for the correction of color blindness. E.J.V.

Explosive nature of silvering solutions. ARTHUR LAURENT. *Diamant*, **51** [15], 288–89; [21], 404–405; [23], 442–44; [25], 481–83 (1929).—A discussion of the various silvering solutions and processes is presented. In L.'s opinion the process yielding the best and quickest results is the nitric acid one. The silver hydroxide produced by the precipitation with alkali is not explosive, nor is the oxide itself. Using a drying apparatus, in which hot air is the drying medium, it is possible to turn out a mirrored surface

that is completely lacquered and varnished in about 15 minutes. See also *Ceram. Abs.*, **9** [1], 24 (1930). E.J.V.

Source of danger of explosion in chemical silvering of glass. EDUARD LOHMANN. *Diamant*, **51** [27], 526–30 (1929).—The danger of explosion is said to lie in the preparation of the ammoniacal solution of silver for the Brashear process, when solution "A" is made alkaline with potassium or sodium hydroxides. In certain concentrations the compound $Ag(NH_3)_2OH$ is formed, which breaks down to give silver amide, $AgNH_2$, and silver nitride Ag_3N. This does not happen in dilute solutions, containing less than 0.35 g. atoms of Ag per liter. The mixture of silver amide and nitride, the "Knallsilber" of Berthelot, detonates violently on the slighest disturbance of the solution. In the Rochelle salt process, where additions of caustic alkali are unnecessary there is very little danger of the formation of this explosive compound, and the danger in the Brashear can be minimized to a large extent by avoiding too concentrated solutions of silver, using dilute (1100) caustic alkali and mixing the solution only just before use. It is also good practice to keep the flasks which contain such solutions away from direct exposure to sunlight. E.J.V.

Danger of explosion in silvering solutions. MAX ERMES. *Diamant*, **51** [30], 587 (1929).—The statements of E. Lohmann in regard to the immunity from danger of explosions in the Rochelle salt process are confirmed by E. He knows of mirrors prepared by this process that are still sound though they were prepared 20 yrs. ago. Experience with a solution that had been stored for a year confirmed the fact that the Brashear process is also safe if the solutions are properly diluted. See preceding abstract; also *Ceram. Abs.*, **9** [1], 24 (1930). E.J.V.

Manufacturing program of the drawn-glass industry. E. STANG. *Glashütte*, **60** [3], 37–38 (1930).—Recent developments in the mechanization of this industry in Germany are reviewed. L.T.B.

Stony glass. L. SPRINGER. *Sprechsaal*, **63** [25], 464–66; [26], 484–86 (1930).—S. describes different types of stony glasses which were tested microscopically and chemically. The following cases were investigated: (1) grog and frit stones in blown window glass; (2) frit and grog stones in drawn pane glass; (3) again, frit and grog stones in window glass; (4) frit stones in blown window glass; (5) lime stones in drawn pane glass; (6) grog stones in cast plate glass; (7) frit stones in lead crystal glass; (8) liberated borax in lead crystal glass, containing borax; (9) frit and grog stones in lead crystal glass; (10) devitrification stones in lead crystal glass; (11) stony bottle glass; (12) deposits of dinas stones in ordinary hollow glass. The chemical compositions of the investigated stones are given. The article is illustrated. M.V.K.

Combustion in regenerative glass tanks. JOHN W. ROMIG. *Ceram. Ind.*, **15** [1], 54 (1930).—R. states that when glass conditions change from good to bad for no apparent reason it is often the fault of the combustion in the tank. In the case of producer gas-fired regenerative glass tanks combustion conditions depend upon the producer gas and amount of air admitted to the combustion chamber. Control is best exercised by waste gas analyses for CO, CO_2 and O_2, with O_2 as the safest index to proper combustion. Practically no CO should be in the waste gases. Operation should be with an excess air content of from 25 to 50%. The oxygen in the waste gases should be kept as low as possible without allowing CO to be present. W.W.M.

Absorption of gas mixtures by glass. C. DRÜCKER AND J. MARXEN. *Z. physik. Chem.*, **147** [5], 371–89 (1930).—The speed and amount of hydrogen and carbon dioxide which are absorbed by dry and moist glass surfaces from the pure gases and from mixtures of the two was measured at 25°C and at various pressures. L.T.B.

Theory of glassblowing and glassdrawing. H. SCHLECHTWEG. *Sci. Abs.*, **33**, 227 (1930); for abstract see *Ceram. Abs.*, **9** [1], 25 (1930). D.E.S.

Absorption of glasses in the ultra-violet region. P. GILARD AND P. SWINGS. *Bull. Acad. Roy. Belg.*, **5** [15], 749–55 (1929).—Details are given of a simple method of determining the percentage transmission of ultra-violet light by glass. An examination of a number of glasses indicates that the transmission is increased by the presence of nickel oxide and that barium oxide is more effective than calcium oxide in producing transparency in the region 2700 to 3300 Å. (*B.C.A.*)

Glassware finishing. H. A. DONALDSON. *Ind. Finishing*, **5** [12], 27–30 (1929).—The application and fixation of color finishes and color decorations to a variety of articles included in modern glassware are discussed. (*C.A.*)

Electrical eye detects weak spots in glass. ANON. *Nat. Glass Budget*, **46** [9], 3 (1930).—Great savings will be effected for the glass industry through the recent development of an "electrical eye," an instrument which accurately detects the weak spots, as well as the degree of their weakness, in glass bottles. The "electrical eye" was recently placed in operation at Alton, Ill. Rights to the instrument will not be granted exclusively to any company but will be at the disposal of "anyone who wants to use the instrument." E.P.R.

Strength of glass containing cracks. L. H. MILLIGAN AND F. W. PRESTON. *Jour. Soc. Glass Tech.*, **14** [53], 37–38 (1930).—P. discusses the results of experiments performed by M. G.R.S.

Rate of crystal growth in technical soda-lime-silica glasses. III. ADOLF DIETZEL. *Glass Ind.*, **11** [7], 156–59 (1930).—Additional tables and figures are presented, as is a discussion of the influence of thermal history on the rate of crystallization. For Part II see *Ceram. Abs.*, **9** [8], 625 (1930). E.J.V.

Effect of repeated melting in platinum on properties of soda-lime-silica glass. V. DIMBLEBY, H. W. HOWES, W. E. S. TURNER, AND F. WINKS. *Glastech. Ber.*, **7** [12]. 582–88 (1930); for abstract see *Ceram. Abs.*, **9** [7], 515 (1930). E.J.V.

Glass insulators. F. NIETHAMMER. *Glastech. Ber.*, **7** [12], 588–89 (1930).—A comparison was made of first-class glass insulators (including "Pyrex") with porcelain insulators. The results of tests showed the insulating value of glass to be higher than porcelain, the puncture value to be higher, and the spilling-over value equal to that of porcelain. The dielectric loss and angle-of-loss values could not be differentiated between for the two materials. The loss increases more rapidly with temperature increase in glass insulators, and the surface of the glass is more susceptible to atmospheric attack. A great advantage of glass is its transparency, making the detection of defects easy. Applications of glass insulators are discussed. E.J.V.

Firing of tanks. F. JOCHIM. *Glastech. Ber.*, **7** [12], 553–69 (1930); *Diamant*, **51** [36], 705 (1929).—The field of firing of tank furnaces cannot be exhaustively treated in a short discussion on account of its many-sidedness. The operation of a tank is difficult because the limits of efficiency cannot be determined easily. Knowledge acquired through experience in the industry must be applied. Experiments in trying to increase the service of tanks through changes in the firing are limited because of structural proportions, length of flame and width of hearth, stability of refractory materials, etc. The physical conduct of the glass in the molten state also prohibits an increase of tank service above fairly closely drawn limits. The value of tank service normally to be obtained moves between limiting values and it is known that the tank service is influenced by the method of operation. The responsibility of the furnace operator begins with the insertion of the glass raw material. There are different methods and devices for loading which require a critical judgment in making a choice. Here again experience must be consulted, as the views of technicians vary. The firing and temperature distribution over the hearth are especially important, as the temperatures must have a definite course in the melting of glass; otherwise undesirable currents are apt to be set up in the

glass, leading to poor glass. In many cases the furnace operator must understand how to remove structural defects, which adhere to the tank as inherent defects. Aids to fine control are primitive at present and occasionally lead to unnoticed defects which must be referred to as in many cases this danger is not sufficiently understood. Gas-forming media make an exact measurement difficult, as they are influenced by pressure, temperature, moisture, and by the fuel gas as well as the calorific value. E.J.V.

Notes on various old glasshouses. F. BUCKLEY. *Jour. Soc. Glass Tech.*, **14** [53], 30–37 (1930). G.R.S.

Specific heat of "Pyrex" glass from 25 to 175°C. T. DEVRIES. *Ind. Eng. Chem.*, **22** [6], 617–18 (1930). R.G.M.

Glass research in 1928. W. MYLIUS. *Sprechsaal*, **62**, 667–80, 696–99 (1929).—A review. (*C.A.*)

Evolution of American plate-glass industry. FRANK W. PRESTON. *Glass Ind.*, **11** [7], 151–52 (1930).—The plate-glass industry has undergone exceedingly rapid evolution in the past 10 yrs. Where it was formerly confined to the production of $^1/_4$-in. plate glass for store fronts, the advent of the closed automobile in great numbers changed things. To meet the demand for small sizes it was necessary for automobile manufacturers to enter the glass field to insure themselves a supply. Ford developed a new continuous process which was so successful that glass men developed continuous processes to compete. In Europe, the new Bicheroux casting system, the Pilkington continuous grinding and polishing machines, and similar developments are being used and these ideas have recently been adopted in America. The popularization of "unshatterable" or "laminated" glass caused a shift to the production of $^1/_8$-in. glass. The gap between the plate and window glass industries has been partly bridged. E.J.V.

Ventilation in glass plants. ERNST PLENSKE. *Glashütte*, **60** [23], 407–409 (1930).—Discussion of some of the problems encountered in proper ventilation of glass plants. L.T.B.

Giant quartz mirror. ANON. *Glass*, **7** [4], 147 (1930); for abstract see *Ceram. Abs.*, **9** [5], 342 (1930). H.W.A.

Works of the Heat Technical Council of the German glass industry. H. ILLIES. *Feuerungstechnik*, **18** [11–12], 118–20 (1930).—The Heat Technical Council of the German glass industry in Frankfurt published a number of charts and tables pointing out errors in the management of glass fusing kilns and how to avoid them to obtain a more economical management. M.V.K.

Antiquity of window glass first produced in 1763. ANON. *Nat. Glass Budget*, **46** [10], 28 (1930).—The first positive evidence of glass manufactured by the ancients was the discovery of four panes that were each 6 in. square at Pompeii in 1763. A history of the development of window glass from that time is given. The earliest glass used for windows was doubtless cast, that used at Pompeii having evidently been cast on a stone. E.P.R.

May production of polished plate glass. ANON. *Glass Ind.*, **11** [7], 163 (1930).—The production of polished plate glass for May, 1930, was 12,571,414 sq. ft., compared with 11,429,728 sq. ft. produced in April, 1930, and 12,681,975 sq. ft. in May, 1929. This shows a slight decline under the figure of a year ago, at which time the business was considered booming. E.J.V.

Polish glass industry. ANON. *Pottery Gaz.*, **55** [637], 1152 (1930).—The glass industry of Poland has been poor for a long time in all branches, and sales last year were 20% lower than in 1928. They are going still lower this year. E.J.V.

Balmer-Westite Co. announces new lines in its "Westite" glassware. ANON. *Amer. Glass Rev.*, **49** [39], 14 (1930).—"Westite" is available in dense white, ivory, pool

green, Ming green, azure blue, royal blue, and black in a multitude of bathroom and kitchen fixtures. E.P.R.

Modern plate glass production. L. VON REIS. *Glastech. Ber.*, **7** [12], 570–76 (1930).—A review of the newer methods of plate glass production, including the methods of the Libbey-Owens Co., the Ford Motor Co., the Showers process of the Pittsburgh Plate Glass Co., and the Bicheroux process, is given in some detail. Not only the methods of producing the glass but also the finishing are described. Illustrated. E.J.V.

Walls of glass and copper. ANON. *Nat. Glass Budget*, **46** [8], 22 (1930).—Inverted pyramids of glass, copper, and concrete with steel furnishings, have been designed by a New York architect, for four 18-story apartment buildings to be erected in New York. From the central core of the building, shelves or floor will extend and over these shelves the glass and copper shell will be constructed. E.P.R.

Glass enclosed cities. E. VERNON HILL. *Nat. Glass Budget*, **46** [7], 27 (1930).—A city roofed in by glass and its temperature and air controlled by a municipal bureau was pictured today as the community of the future, H., an aerology scientist, stated in an address on air pollution before the 36th Annual Meeting of the Amer. Soc. of Heating and Ventilating Engineers. E.P.R.

Coming of the glass age. ANON. *Nat. Glass Budget*, **46** [1], 22 (1930).—"The Dawn of the Glass Age" is the title of an article written by O. O. McIntyre for "New York Day by Day," and later appearing in *The Grinder*. Remarkable progress has been made in experimenting with glass brick. Such brick permit light, but distort vision from outside. Already a half dozen building fronts on Fifth Avenue are almost entirely of glass, both clear and opaque. In London, glass structures are in the making to counteract perpetual fogs. A French perfume importer is negotiating for a 4-story glass building in the East Twenties. A millionaire in Brussels has a glass chateau and a Berlin hotel is shortly to open with an entire glass lobby. All over Europe glass roofs grow in favor. A new hotel is to have all glass bathrooms, and side-walks of glass are being agitated for an entire block on West Fifty-Seventh St. E.P.R.

BOOK

Melting and Forming Glasses. (Schmelzen und Formgebrung des Glases.) HANS JEBSEN-MARWEDEL. 167 pp., 93 figs. Published by Akad. Verlag., Leipzig. Price, 13.20 M. Reviewed in *Rev. belge ind. verrières*, **1**, 87 (1930). A.J.M.

PATENTS

Composition blackboard. FOSTER DEE SNELL. U. S. 1,756,393, April 29, 1930. A composition of matter adapted for use as a blackboard and comprising a vitreous matrix having uniformly distributed therethrough an opaque, inert, and finely divided, somewhat harder granular mineral.

Cooled roll for producing sheet glass. JOHN L. DRAKE. U. S. 1,763,689, June 17, 1930. In sheet glass apparatus, a roll having an opening therethrough, the opening being of such a nature that the wall of the roll becomes progressively thicker from its center toward both ends thereof.

Delivering and shaping molten glass. GEORGE E. HOWARD. U. S. 1,763,968, June 17, 1930. The method of feeding molten glass that comprises successively detaching a series of suspended masses of glass from a parent body, temporarily applying a force to the lower portion only of each mass, after detachment, to retard it sufficiently to prevent substantial elongation thereof, and receiving the mass in a mold.

Polishing machine. FLOYD FLEXON AND CLARENCE CHEW. U. S. 1,764,161, June 17, 1930. The combination of a chuck to hold an article to be polished, means to oscillate the chuck, means to reciprocate the chuck axially in timed relation to oscilla-

tion thereof, and an adjustable device included in the chuck oscillating and reciprocating means to vary the degree of oscillation and reciprocation of the chuck simultaneously.

Glassware-forming machine. STANLEY L. HEWITT. U. S. 1,764,166, June 17, 1930. In combination, a tiltable bottom plate holder comprising a pair of open frames nested one within the other, means separably interconnecting the frames, a pair of bottom plates, and means including a single spring providing a yielding connection between the bottom plates and the inner frame operating at times to effect a sufficient degree of frictional engagement between the plates and holder to prevent relative lateral movement between the elements.

Glass-forming machine. RICHARD LA FRANCE. U. S. 1,764,268, June 17, 1930. The combination of a blank mold, a neck mold, means for introducing a charge of glass into the molds, a rod projecting into the molds and having a screw-threaded or spiral-surface formation for forming a threaded surface on the interior of a blank within the molds, mechanism including a train of gears for imparting to the rod a combined rotative and lengthwise movement for withdrawing it from the mold, mechanism for imparting a straight line movement of the rod away from the mold, and an actuating device connected to the mechanisms and arranged to operate them in succession by a single movement of the actuating device.

Glassblowing machine. LEONARD D. SOUBIER. U. S. 1,764,360, June 17, 1930. The combination of a blank mold, a neck mold, a plunger, means to project the plunger downward within the blank mold, means to charge the mold beneath the plunger by suction, the lower end of the plunger being substantially the same diameter as the mold cavity, whereby the glass entering the mold is prevented from passing upward past the plunger, means to withdraw the plunger, means to cause the glass to follow upward with the plunger, a neck mold, a shaping member surrounding the plunger and forming with the neck mold a neck cavity in which the glass is molded to form the neck of the article, and means to withdraw the plunger and the shaping member from the neck mold.

Glass-forming machine. LEONARD D. SOUBIER. U. S. 1,764,361, June 17, 1930. The combination of a mold, a plunger projecting into the mold through one end thereof and having a surface formation corresponding to the interior surface of the article to be formed, the mold and plunger together providing a mold cavity closely approximating the size and shape of the finished article, means for introducing molten glass by suction into the mold through the end thereof opposite to that through which the plunger projects and thereby substantially completely filling the mold cavity, means for severing the glass at the filling end of the mold, a closure plate movable into position to close the filling end, and means for forcing the plunger further into the mold while the closure plate is in mold-closing position and thereby compressing the glass in the mold.

Conveyer drive for glass-annealing leers. HENRY W. INGLE. U. S. 1,764,791, June 17, 1930. The combination with a conveyer of woven wire fabric for transporting articles of glassware, of a drum of relatively large diameter provided with a resilient anti-slipping covering for driving the conveyer and a roller for maintaining the conveyer in contact with the drum through a major portion of the periphery thereof, the drum and the roller being both positively driven, to provide a large surface of driving contact for the conveyer.

Increasing the production of glass. FRANCIS C. FLINT. U. S. 1,764,832, June 17, 1930. The method of increasing the production of glassware which consists in arranging the forming machines on two different levels, the two levels being spaced a vertical distance at least greater than the height of the forming machines, and dropping glass charges vertically from a tank to the forming machines on both levels.

Optical glass. MURRAY R. SCOTT. U. S. 1,765,287, June 17, 1930. A dense

barium crown optical glass which is resistant to tarnishing comprising over 25% of barium and under 5% of a zirconium compound.

Cutting sheet glass. LAMBERT VON REIS. U. S. 1,765,552, June 24, 1930. A device for cutting sheet glass, comprising in combination a conveyer for the sheet glass, a drop knife arranged for sliding movement in the direction of travel of the conveyer at one side thereof, knife supporting rails at one of the longitudinal edges of the conveyer, transverse interstices in the conveyer and in the knife supporting rails into which the knife is adapted to drop for cutting the sheet glass, and means on the conveyer for engaging the knife and carrying it along with the conveyer during the cutting operation.

Separating glass sheets. CHARLES H. WRIGHT. U. S. 1,765,814, June 24, 1930. Apparatus for cracking off sections from a forwardly moving sheet or ribbon of glass comprising a bar extending transversely of the sheet provided with a heating ribbon and adapted to move with the glass during the heating operation, a chilling tool carried by the bar, and mounted for movement toward and from the sheet, so that, in one position, it touches the sheet on the line at which the ribbon has engaged the sheet, and means for giving the tool its movement toward and from the sheet.

Making composite glass. JOHN H. FOX AND WILLIAM OWEN. U. S. 1,765,829, June 24, 1930. Apparatus for applying heat and pressure to a plurality of sets of glass sheets and reënforcing layers there-between, comprising a carrier mounted for movement, a power press carried thereby, having a fixed base and a vertically movable top to which the pressing power is applied, a track mounted on the carrier transversely thereof beneath the top, an assembling table at one side of the carrier, a runway on the assembling table with which the track is aligned by the movement of the carrier, and a car on the runway on which the sheets to be pressed are stacked, the track being mounted for vertical movement so that after the car is positioned beneath the press top, it may be lowered to bring its body portion into engagement with the fixed base.

Severing composite glass, etc. WILLIAM OWEN. U. S. 1,765,846, June 24, 1930. In combination, a machine for cutting curves in sheets of hard material, comprising a fixed table adapted to support the sheet to be cut, a template extending longitudinally of the table fixed with respect thereto and having a contour corresponding to the desired line of cut, a carriage mounted for movement longitudinally of the table and also transversely thereof, coöperating means between the template and the carriage whereby the carriage is caused to follow the line of curvature of the template, as such carriage is moved longitudinally of the table, means for giving the carriage its movement longitudinally of the table, and a thin, driven cutting disk mounted upon the carriage in position to engage and cut the sheet.

Blowing thin-wall glassware. JAMES W. LYNCH. U. S. 1,766,135, June 24, 1930. In a glassware-forming machine, the combination of separable blank molds and solid blow molds movable to successive operating stations including a transfer station, the blank and blow molds being so positioned that the blank mold is directly above the blow mold at the transfer station, separable neck rings associated with the blank molds, separable bust-off rings associated with the blow molds, the blow mold having its bust-off rings open at the transfer station, means for disengaging the blank mold from the blank, means for closing the bust-off rings over the upper end of the blow mold, and means for disengaging the neck rings from the blank to permit the latter to drop into the blow mold and be engaged by the bust-off rings.

Sheet glass-cutting machine. WILLIAM H. CLELLAND. U. S. 1,766,427, June 24, 1930. In a machine, a plurality of traveling devices, forming elements carried thereby, rollers mounted beneath the upper run of the traveling devices, means for imparting movement to the traveling devices, rotary glass-cutting means including connected and intersecting longitudinal and circumferential cutting elements, the cutting means

being mounted above the rollers and above the upper run, and means for imparting movement to the cutting means.

Coated glass plate. CARL GRAMBACH. U. S. 1,766,509, June 24, 1930. A glass body comprising a body having a rear face and a bezeled marginal edge bounding the rear face, a coating covering the rear face up to the line of intersection of the rear face and the bezeled marginal edge, and a protective layer covering the outer surface of the coating and extending beyond the latter into adhering contact with the bezeled marginal edge.

Leer. WILLIAM STANLEY RENDALL. U. S. 1,766,545, June 24, 1930. In a muffle leer for annealing glassware a tunnel having insulated top, side, and bottom walls, a muffle flue formed in one of the walls, and an auxiliary wall within the tunnel, the last-named wall being separate from the first-named walls and the flue.

Handling glassware. DANIEL B. WESTIN. U. S. 1,766,573, June 24, 1930. Apparatus for removing glassware from molds comprising a vertically disposed guide, a member mounted for movement in the guide, a supporting arm and a guiding arm pivotally connected at their upper ends to the member on laterally offset axes, the arms forming a parallel-motion system, a ware-supporting device having pivotal connection with the lower ends of the arms, and a crank device rotatable about a fixed axis and pivotally connected to one of the arms between the ends thereof.

Handling glassware. DANIEL B. WESTIN AND HENRY W. INGLE. U. S. 1,766,574, June 24, 1930. Apparatus for handling glassware comprising a support, a carriage mounted on the support for movement thereon toward and away from a ware-receiving station and a ware-delivering station, ware-transferring means mounted on the carriage, means for moving the transferring means about a horizontal axis to transfer ware from the receiving station to the ware-delivering station, ware-holding means mounted on the transferring means, and means for actuating the holding means at the stations to grasp and release the ware.

Drawing glass tubing. GEORGE E. HOWARD. U. S. 1,766,638, June 24, 1930. (1) Apparatus for drawing glass tubing comprising means for causing molten glass to flow downwardly in an annular stream, a former for shaping the descending stream into a tube of approximately the desired diameter, means for subjecting the initially formed tube to subatmospheric pressure, a plurality of spaced sizing members for compressing the tube to its final diameter, and means for applying subatmospheric pressure to the tube in the intervals between the sizing members. (2) Apparatus for drawing glass tubing comprising means for establishing a descending annular stream of molten glass, means for forming the stream into a solidified tube, and means for applying downward traction to the tube, the traction means comprising two clamps, means for reciprocating each of the clamps vertically, and a burner carried by one of the clamps for severing the glass tube into lengths. (3) Apparatus for drawing glass tubing comprising a receptacle having a downwardly opening discharge outlet, an annular member disposed below the outlet and adjustable vertically therebeneath, the annular member, when in its upper position, forming a substantial continuation of the discharge outlet, means for cooling the annular member, and a vertically adjustable plug disposed above the discharge outlet and having a lower end adapted to chill the glass flowing in contact with the lower end.

Glass ribbon-feeding apparatus. SIDNEY F. PARHAM. U. S. 1,766,680, June 24, 1930. In the process of manufacturing glass articles from a ribbon of molten glass, the steps of forming a glass ribbon which is adapted to assume an arcuate path when lying in its own plane by forming the ribbon at a progressively differential speed from one edge to the other thereof, and thereafter depositing the ribbon in an arcuate path in its own plane.

Movable glass-delivery chute. ROBERT W. CANFIELD. U. S. 1,766,979, June 24,

1930. In glassware making apparatus, means for feeding charges of molten glass, means for forming the charges of glass into glassware, a movable chute for delivering the charges of glass from the feeding means to the forming means, the forming means having a head adapted to assist in the forming of the glassware, the head being movable, and means operated by a movement of the head for moving the chute.

Sheet edge-forming device. JOSEPH A. REECE. U. S. 1,767,094, June 24, 1930. In sheet glass apparatus, means for drawing a sheet from a mass of molten glass, including pairs of rolls, having smaller circumferences at their centers than at their ends, engaging the respective sheet edges.

Coloring thin glass bodies. EDWARD A. ZEH. U. S. 1,767,108, June 24, 1930. In the art of fusing a decalcomania to a thin hollow glass body, the method which consists in subjecting the glass body to heat at a temperature sufficiently high to cause the decalcomania to fuse into the glass and at a temperature less than the temperature at which the glass sags, while absorbing heat from the lower portion of the glass body thereby to minimize the tendency of the lower portion of the glass body to sag under its own weight.

Glass-surfacing apparatus. JOHN L. DRAKE. U. S. 1,767,123, June 24, 1930. In combination in sheet glass-surfacing apparatus, a table for carrying the sheets to be surfaced in a definite substantially horizontal path, a surfacing tool arranged to rest upon the sheets, a frame work having a main center bearing, a bushing journaled within the bearing above the table, a vertical spindle carrying the surfacing tool at its lower end and being journaled within the bushing eccentrically thereof, a vertical shaft centrally mounted in the top of the frame work and eccentrically arranged with relation to the spindle, a plurality of universal connections between the shaft and spindle, a worm gear carried by the bushing, a worm meshing with the worm gear, means for driving the shaft to impart rotary movement to the spindle, and operative connections between the driving means and the worm for rotating the bushing to cause a shifting circular movement of the surfacing tool upon the sheet.

Glass-rolling machine. HARRIS B. HOLT. U. S. 1,767,131, June 24, 1930. In a glass-rolling machine the combination of a table and a truck movable relatively to the table, the truck including a body portion which throughout the range of truck movement is disposed beyond one end of the table, and including also parallel arms which in the range of truck movement advance and recede along the sides of the table, glass-spreading means mounted upon the arms of the truck and in the range of truck movement advancing above the surface of the table, truck-driving means including a motor borne by the body of the truck, and driving connection between the motor and glass-spreading means.

Conveying strips, sheets, or plates of glass. SÉRAPHIN WEROTTE. U. S. 1,767,907, June 24, 1930. A glass-rolling apparatus comprising in combination a pair of rolling cylinders and a set of conveying rollers, means to conduct the rolled strip, sheet, or plate from the rolling cylinders to the conveying rollers and a receiving member supported on the conveying rollers and adapted to receive the leading edge of the rolled strip, sheet, or plate and support the leading edge during the travel of the strip, sheet, or plate on the conveying rollers.

Conveying glass from forming devices. LOUIS BOUDIN. U. S. 1,767,913, June 24, 1930. The combination with a leer, of two machines for forming discontinuous glass sheets, a mechanism for receiving sheets from either of the machines, comprising a carriage mounted for turning about a central vertical pivot and carrying a plurality of sheet supporting rollers located in front of the leer and having their axes parallel to the line of feed into the leer, and means for driving the rollers at a peripheral speed slightly in excess of the speed of the sheet formation, comprising a shaft mounted on

the carriage and a clutch by which it may be connected to and driven from the drive of either of the sheet-forming machines.

Conveying glass from forming devices. LOUIS BOUDIN. U. S. 1,767,914, June 24, 1930. The combination with a leer, of a machine forming discontinuous glass sheets, and mechanism for receiving the sheets therefrom as formed comprising a plurality of rollers driven at a peripheral speed slightly in excess of the speed of sheet formation, located in front of the leer, and having their axes parallel to the line of feed into the leer.

Glass plate feed track. RICHARD GENENGER. U. S. 1,767,922, June 24, 1930. A bridge for a glass plate feed track, the bridge having a point of contact along one edge thereof and a narrower point of contact on the other edge.

Making tubing. CHARLES E. GITHLER. U. S. 1,767,923, June 24, 1930. The method of making tubing which consists in gathering molten glass on the end of a blow pipe, marvering it, blowing a cavity in the glass, opening the cavity, placing a strip of glass in the cavity, closing the opening, gathering additional glass, elongating, marvering, and drawing out the gather to form tubing of the desired size.

Producing fibers from vitreous materials. JOHN GRANT JACKSON. U. S. 1,769,181, July 1, 1930. In a method of producing fibers from vitreous material the step which consists in assembling elongated fibers of such material and passing same through a composite melting and drawing gas blast adapted to attenuate and elongate such fibrous material while in a molten state.

Manufacturing sheet glass. HERMANN MÜLLENSIEFEN. U. S. 1,769,451, July 1, 1930. An apparatus for manufacturing sheet glass, comprising a body formed with an elongated slot and adapted to float on the body of glass, the body being formed with bores disposed transversely of the slot, means for drawing a band of glass through the slot, means for supplying wires through the bores and into the band of glass, and means for preventing access of the molten glass to the wires being supplied to the bores.

Glass conveyer. JULES MAYEUR, SR. U. S. 1,770,039, July 8, 1930. A glass conveyer including a substantially rectangular frame whose top is open, transverse shafts journaled in bearing openings in the ends of the frame and carrying sprocket wheels, spaced series of rollers having trunnions journaled in the sides of the frame, endless sprocket chains trained around the sprocket wheels and bearing on the rollers, the links of certain of the chains being formed with cross-sectionally U-shaped brackets, cross-sectionally U-shaped flights received in and secured to the brackets and the flights having their lower corners formed with finger extensions, the flights receiving therein sheets of asbestos which project through the open top portions thereof and which are secured to the flights and to the brackets, cross-sectionally U-shaped continuous guides fixed to the inner faces of the frame and receiving the fingers therein and the ends of the guides being rounded and terminating inward of the shafts, and means for imparting a rotary motion to one of the shafts and for transmitting such motion to the rollers and to the remaining shafts.

Making blown-glass articles. KITSUZO FUWA. U. S. 1,770,335, July 8, 1930. The method of manufacturing veneer glass articles which consists in flowing streams of glass from a plurality of containers to form a ribbon comprising a plurality of layers of plastic glass and then punching blanks from the ribbon and blowing the blanks into the desired articles.

Compound transparent sheets. J. JEFFRAY. Brit. 327,949, June 12, 1930. In the manufacture of splinterless glass, the glass sheets with the cellulose acetate, etc., sheets interposed are placed between flexible covers, and the air is exhausted from between the covers and heat is applied so that the sheets are pressed together by the pressure of the external atmosphere. The compound sheets are held between flexible sheets of

rubber, balata, etc., which are clamped by their edges in a frame. The air is exhausted from inside the flexible bag. The lower flexible sheet rests on an openwork plate and electric heating elements resting on an asbestos sheet lie beneath the openwork plate within the frame.

Glass furnaces. G. C. MARKS. Brit. 327,976, June 12, 1930. In an apparatus for the heat treatment of bottles, and more particularly adapted for setting the silver coating of vacuum bottles, the goods are freely exposed on a carrier device to air currents, which are heated by burners or other devices within the oven. The apparatus shown comprises a double-walled insulated casing through which moves an endless conveyer having a cooling section freely exposed to the air. The lower wall of the heating chamber consists of a wire screen supporting sheet asbestos and between this and the upper lap of the conveyer are transverse burner pipes, longitudinal hot air distributing pipes, and a perforated metal heat-equalizing screen. Gases are withdrawn from the heating chamber through hoods and are returned by a fan. The conveyer comprises side chains connected by cross bars carrying end rollers running on rails and wire loops shaped to support vacuum flasks with their unsealed tips extending beneath the wires. The delivery nozzles of the burners are made by inserting toothed wheels cut from pinion wire in circular holes drilled in the tube. Fuel is supplied under pressure through the connection and draws in air through the nozzle.

Metallizing glass surfaces. G. C. MARKS. Brit. 328,217, June 18, 1930. The surfaces of a glass container, and particularly the walls of the annular chamber of double-walled vacuum vessels, are coated with a mirror-like film of metal by vaporizing metal placed in proximity to the whole of the surface to be coated. The metal employed is preferably magnesium, but in certain circumstances, gold, silver, barium, calcium, cerium, germanium, antimony, zinc, cadmium, lead, bismuth, thallium, sodium, copper, aluminium, nickel, cobalt, tungsten, molybdenum, or tantalum may be used. The metal is preferably in the form of one or more wire cages, loosely fitting about the inner container, the cages being formed of spaced coils with the ends of the wire connected to the various coils so as to form a series of short-circuited coils. Spacing pads of heat-insulating and shock-absorbing material such as asbestos, or beads of soft metal strung on the wire and preferably coated with a layer of oxide, are inserted. The coil is adapted to be electrically heated, preferably by induction from a primary coil surrounding the bottle and connected to a source of high-frequency current. Before vaporizing the metal, the bottle is heated to the highest temperature the glass will stand under pressure, and the chamber is exhausted. The bottle may be sealed either before or after vaporization of the metal.

Glass manufacture. C. G. BROOKS. Brit. 328,432, June 18, 1930. A borosilicate glass which is resistant to chemical and thermal changes is made by melting a batch containing less than 70% of silica, more than 6% of alumina, and a moderate amount of boric oxide together with at least three oxides of bivalent metals and at least three oxides of monovalent metals. A suitable batch comprises 65% silica, 10% alumina, 10% boric oxide, 3% sodium oxide, 4% potassium monoxide, 2% lithium oxide, 1% magnesium oxide, 2% zinc oxide, 1% barium monoxide, and 2% calcium oxide.

Glass manufacture. L. MELLERSH-JACKSON. Brit. 328,443, June 18, 1930. Relates to apparatus for circulating molten glass in a gathering pool or forehearth, particularly for use in connection with glassworking machines which gather charges of glass by suction. According to the invention, a vertical or inclined rod or impeller dips into the glass and is moved in a path passing through the point at which gathers are made, so that the chilled glass is removed from this point between successive gathers.

Pressing glass. W. B. MITCHELL. Brit. 328,445, June 18, 1930. Relates to a rotary pressing apparatus and consists in forming each mold so that several articles

are produced simultaneously, and in forming each pressing plunger so that it is used to eject the finished articles from the molds.

Glass manufacture. H. SEABROOK. Brit. 328,520, June 25, 1930. Glass for absorbing ultra-violet and infra-red rays is made by adding cobalt oxide and iron oxide to a batch for producing glass which is substantially colorless, and melting the batch under reducing conditions. The iron oxide is generally in the form of ferrosoferric oxide, and the proportion of each oxide is generally not less than 0.3% of the weight of the finished glass. The absorption of the heat rays is increased by adding arsenic or antimony oxide, the proportion of each being not less than 0.5% of the weight of the finished glass. For reducing purposes, carbon or other organic substances, or a small quantity of tin chloride, is added to the batch. The glass may be used in a screen for viewing incandescent bodies, and the color of a radiant body when seen through the glass is faintly blue.

Compound glass. SALOMON SINGER. Austrian 117,082, Nov. 15, 1929. A sheet of celluloid is secured between 2 sheets of glass by means of an aralkyl alcohol, *e.g.*, benzyl alcohol. The celluloid is soaked in the alcohol, the glass sheets are applied and the whole is then lifted from the bath and pressed at 60 to 80°. Other swelling agents for celluloid may be mixed with the alcohol. (*C.A.*)

Safety glass. THE BRITISH SAFETY GLASS CO., LTD. Fr. 677,808, July 3, 1929. A transparent film of regenerated cellulose is fixed between surfaces of glass, and adhesive agents, which do not dry or practically not or which are not volatile or only slightly volatile and which have no solvent action on the film, are used. Examples are strong glue dissolved in water or gelatin treated in water with AcOH or HCOOH. (*C.A.*)

Safety glass. HENRY DREYFUS. Fr. 677,261, June 25, 1929. The intermediate cellulose derivative sheet in safety glass is treated with a medium comprising a non-solvent of the cellulose derivative and plasticizer thereof by dipping before uniting by heat and pressure. The glass may be coated with gelatin, gum, resin, or cellulose ester solution. The plasticizer may consist of methylated spirit and triacetin with or without glycol diacetate or a mono-ether of ethylene glycol. The edges of the compound sheets may be sealed by solutions of acaroid resin or gum mixed with a cellulose derivative solution. (*C.A.*)

Safety glass. ACETEX SAFETY GLASS, LTD. Fr. 677,389, June 25, 1929. A composite sheet of a cellulose derivative such as cellulose acetate is fixed between 2 sheets of glass by damping the composite sheet with a plastifying agent or solvent of high boiling point, pressing the sheets together by means of an inert gas under pressure, and then by steam under pressure, the temperature of the steam being below the boiling point of the plastifying agent or solvent. (*C.A.*)

Safety glass. THE BRITISH SAFETY GLASS CO., LTD. Fr. 677,404, June 25, 1929. The sheets of glass and the intermediate sheet of a cellulose derivative are coated with an adhering substance such as glue, gelatin, fish glue, albumin, gum, or resin or a mixture thereof with a solvent such as HCOOH or AcOH, and then pressed together with heat. (*C.A.*)

Safety glass. THE BRITISH SAFETY GLASS CO., LTD. Fr. 677,674, July 1, 1929. Cellulose regenerated in water, *e.g.*, from a solution of viscose, or viscose-Mg or viscose-NH_4, is used as the intermediate sheet in composite safety glass sheets. The cellulose may be treated with CH_2O and bleached. (*C.A.*)

Heavy Clay Products

Method for determining loss of weight of clays during firing. W. R. MORGAN. *Jour. Amer. Ceram. Soc.*, **13** [8], 561–65 (1930); for abstract see *Ceram. Abs.*, **9** [3], 181 (1930).

Clay sewerpipe manufacture. IX. Method of checking flue-gas analyses and its application to ceramic kilns. E. A. HERTZELL. *Jour. Amer. Ceram. Soc.*, **13** [8], 566–70 (1930); for abstract see *Ceram. Abs.*, **9** [3], 182 (1930). **X. Measurement of moisture loss in kilns.** ROBERT L. BLESSING. *Jour. Amer. Ceram. Soc.*, **13** [8], 571–79 (1930); for abstract see *Ceram. Abs.*, **9** [3], 182 (1930). **XI. A simple and inexpensive cold-junction compensator for outdoor pyrometer installations.** R. E. ARNOLD. *Jour. Amer. Ceram. Soc.*, **13** [8], 580–86 (1930).—This paper describes an inexpensive, simple, and satisfactory method for multiple kiln installations to correct for cold-junction temperature variations. For Parts VI, VII, and VIII see *Ceram. Abs.*, **8** [7], 500 (1929).

Discussion of paper by F. T. Heath, "Standard unit of dimension for masonry." JOHN BURCHARD, 2ND, AND A. F. BEMIS. *Jour. Amer. Ceram. Soc.*, **13** [8], 587–93 (1930).—The authors have stated in what sort of buildings a standard unit of dimension of masonry would be practical and the advantages of cubical modular planning with a common denominator of dimensions.

Side lines for paving brick. WM. C. PERKINS. *Clay-Worker*, **93** [7], 488–90 (1930).—Paving brick are used on small construction projects, which in the aggregate use a great many. They are used in gutters of asphalt-paved streets, paving bridges and grade elimination viaducts, railroad paving, paving dams, reservoir slopes and the surfacing of piers, the paving of factory floors, and landscape work. Illustrated. E.J.V.

Haydite production. ANON. *Clay Prod. News*, **3** [5], 12 (1930).—The production of "Haydite" a light weight, thoroughly vitrified, cellular, patented building material was begun in Ontario in 1929. The product may be used as aggregate for any type of monolithic concrete construction, or it can be molded or cast into blocks, mixed with cement mortar as a binder. The resultant product is much lighter than hollow concrete blocks, and is soundproof and fireproof. W.C.O.W.

New light brick. ANON. *Tonind.-Ztg.*, **54** [43], 717–18 (1930).—Among the latest innovations in the manufacture of light brick is the use of transverse instead of longitudinal perforations. The nonporous standard size brick (25 x 12 x 6.5 cm.) now has as many as 105 transverse holes and weighs 1.9 kg. The large size (30 x 40 x 12 cm.) has 144 perforations and weighs 5.3 kg. The perforations are sealed at each end giving the appearance of the ordinary building brick. Different makes of this brick are described. M.V.K.

Lime in clay. OSKAR LECHER. *Brick Clay Rec.*, **76** [12], 772–74 (1930); for abstract see *Ceram. Abs.*, **9** [1], 37 (1930). E.J.V.

Experiments on porous concrete. C. R. PLATZMANN. *Rev. mat. constr. trav. pub.*, No. 247, pp. 145–48 (1930).—An agent is added to generate gas when the mixing water is added. The American process utilizes powdered aluminum while the German process uses zinc and calcium chloride. Other gasifying agents were found to be less satisfactory. A.J.M.

Crushing strength of brick and tile piers. STRUCTURAL CLAY TILE ASSN. *Brick Clay Rec.*, **76** [12], 783 (1930).—A summary of actual crushing strength test results on masonry piers of clay tile and Detroit common brick shows the following averages: (1) the solid brick piers developed an average strength of 864 lbs. per sq. in. with an average factor of safety of 5.7 on a design working load of 150 lbs. per sq. in.; (2) the all-tile and brick-faced tile piers developed strengths of 489 to 920 lbs., averaging 661 lbs. per sq. in. with factors of safety of 5.4 to 10.3 averaging 7.34 based on a design working load of 90 lbs. per sq. in.; (3) the deflection of the solid brick piers is a little over $^1/_{16}$ in. in 10 ft. of height under the 150-lb. design working load; (4) the deflection of tile and brick-faced tile piers is a little under $^1/_{32}$ in. per 10 ft. of height under the 90-lb. design working load, or less than half the deflection in solid brick piers. Such slight

deflection is negligible; (5) the more flexible pilasters allow a more uniform distribution of loads and consequently a greater portion of the sectional area of the units used, permitting higher ultimate loads; (6) nailing plugs have little or no effect on the strength of the pier; (7) the strength of the brick used in capping the tile piers greatly affects the strength of the piers; (8) tile piers loaded to 90 lbs. per sq. in. have a higher average factor of safety than Detroit common brick piers loaded to 150 lbs. per sq. in.; (9) piers can be built of tile large enough to do the work of smaller solid brick piers, and due to lighter weight and economy in labor and mortar the cost will be less than that of brick. E.J.V.

Processes for molding clay. ANON. *Sci. Supp.*, **71** [1835], 12 (1930).—A brief outline of a process of heating clay to the point of vitrification and then rolling it into the desired form or pressing it into molds. The method was devised by J. B. Shaw. G.R.S.

Brick floor covering to resist acid action. ANON. *Ind. Engineering*, March, 1930; *Ceram. Ind.*, **14** [6], 682 (1930).—The surface of a concrete floor is coated with asphalt and overlaid with brick first dipped half their depth in asphalt and then pushed into place so that the small joint cracks are filled. W.W.M.

Partly-hollowed brick suggested. GEORGE KISSINGER. *Brick Clay Rec.*, **76** [12], 769 (1930).—The brick that K. introduces make reductions in weight and cost, by molding a brick of standard size, with less clay, using the arch or corrugated wall construction to give the required strength. The brick are so designed that walls are approximately of equal thickness, insuring uniform drying and firing, the thickness of the walls being half the thickness of a standard brick which reduces fuel cost and speeds the brick through the drier and kiln. The brick using the principles of "corrugation" have voids or air cells in both top and bottom of the brick, neither running entirely from one face to the other. There is a continuous bearing face on the four sides of top and bottom with a cross-wall to give additional bearing and for the purpose of tying the walls together. The type using the principle of the "arch" has voids on the bottom (as placed); these voids or air cells extend considerably into the brick. The top of the brick (as placed) is similar to standard brick giving a flat surface for mortar. The brick faced with voids on the lower side gives air pockets between the reënforcing cross-walls which form additional bearing surface. These brick have features not obtained by the standard brick as they are at least 25% lighter yet give the requirements necessary for bearing wall masonry. E.J.V.

Tile research recommendations. ANON. *Clay-Worker*, **93** [7], 479 (1930).—The research committee of the Structural Clay Tile Assn. recommended that research should be inaugurated at once to develop the following information: (*a*) influence and control of void area; (*b*) influence of barrier webs; (*c*) number of webs; (*d*) location of same; (*e*) general thickness of material; all to determine the effect in design for the ideal fire wall based upon maximum fire-resistance periods and for establishing effects with reference to (1) heat transfer, (2) wall rigidity, (3) salvage value, and (4) minimum thickness of outside shells to withstand shattering during exposure under fire and steam. E.J.V.

Possibilities of reënforced brickwork. L. B. LENT. *Bldg. Econ.*, **6** [6], 4–7 (1930).—Reënforced brickwork is built by laying the reënforcing steel in the mortar joints when the brickwork is being laid. Just as in reënforced concrete, the steel rods are so positioned as to take the tensile stresses and the completed structure performs much as reënforced concrete does. It has been found that the design formulas for reënforced concrete are equally applicable to reënforced brickwork. E.P.R.

Rapid fire aging. ANON. *Bldg. Econ.*, **6** [6], 1 (1930).—Country homes which have an appearance of great age are always the most interesting to the casual observer.

Whitewashing or lightly painting the common brick exterior walls and chimneys with a single coat of white lead or any one of half dozen specially prepared paints, will age a century in appearance, within a year. Under the action of the elements, the beating of the rain, the freezing of zero weather, the blistering heat of mid-summer, this coating of paint or whitewash gradually wears away in spots. With the dulled red of the brick peering through, the desired effect is effectively produced. E.P.R.

Modernizing in the clay industry. ANON. *Brick Clay Rec.*, **76** [12], 760–65 (1930).—The drain tile division of the clay products industry has been regarded as the least progressive. The General Clay Products Co., a plant in Baltic, Ohio, is remodeled along modern lines. In 1928, the company shipped approximately 1000 cars of tile and could not supply the demand. In 1929, the shipments increased to more than 1200 cars and the shipments for the first four months in 1930 are far in excess of the same period in 1929. A detailed description of the modernizing features installed in the plant is given. Illustrated. E.J.V.

Clay products in American buildings. ANON. *Brick Clay Rec.*, **77** [1], 30–31 (1930).—Photographs showing the modern use of clay products for both exteriors and interiors are presented. E.J.V.

Fired clay brick. ANON. *Brick Clay Rec.*, **77** [1], 26 (1930).—Contemporary American architects are creating a new style of architecture which clearly expresses the tempo of modern times. Clay products manufacturers have endeavored to follow the development in American architecture by presenting to architects products which will best express their genius. Special colors have been developed recently of a metallic nature, such as produced by the Continental Clay Products Corp., the Alliance Clay Products Co., and a few others. Special glazes have been developed of a type which best absorb floodlighting, such as those made by the Hydraulic Press Brick Co., Hanley Co., Fiske & Co., and others, and special shapes have been produced such as those made by the Alliance Clay Products Co., Continental Clay Products Corp., Fiske & Co., Hanley, and others. Hanley Co. and Fiske & Co. have a special size brick, with a $3^1/_4$-in. face dimension and varying in length from $5^3/_4$ to 12 in. These developments of special shapes and special colors in brick point the direction toward which clay-products manufacturers must progress to help develop modern American architecture which is offering so vast a market to clay products. Illustrated. E.J.V.

Modernized brick plants. ANON. *Rev. mat. constr. trav. pub.*, No. 248, pp. 87–90B (1930).—The modernized European plant is described. A.J.M.

History of English brick industry. ANON. *Brit. Clayworker*, **38** [453], 357 (1930); *Tonind.-Ztg.*, **54** [9], 155 (1930).—A short outline of the history of the brick industry in England from "The Bricklayers Trade and Training" is given. Brickmaking introduced by the Romans died completely with their departure and was not revived until the 13th Century with the advent of settlers from Flanders. One of the oldest brick plants was the State plant of Hull which was already in existence in 1303. The most marked development of the brick industry occurred in the second half of the 17th Century with the introduction of Dutch styles by the architect of the king, Wren. M.V.K.

Remains of brickwork in Chinese walls. ANON. *Bldg. Econ.*, **6** [6], 12 (1930).—A striking example of the lasting qualities of brickwork is the Chinese wall. After 2000 yrs., this brick wall is still so well preserved that it provides a barrier from the ocean into the desert 1500 miles way. The walls are faced with brick of the cumbersome hand-made type peculiar to China. It is 60 ft. in thickness at the base, 40 ft. at the top, and is 50 ft. in height. E.P.R.

BOOK

Modern Practical Masonry. E. G. WARLAND. B. T. Batsford Ltd., London, 1929. *Mech. World*, **87** [2266], 540 (1930).—W. has produced a most commendable treatment of

his subject. The ground covered is divided into three main sections: (1) constructional and practical masonry, (2) geometry of masonry, and (3) masonry costing and estimating system. E.P.R.

PATENTS

Cellular fabric. GEORGE B. HINTON. U. S. 1,739,460, Dec. 10, 1929. A cellular fabric comprising a body of adherent bubbles, each having a rigid envelope of set hydraulic cement, the walls of the individual envelopes being of substantially uniform thickness.

Handling brick. EDGAR T. JUDSON. U. S. 1,763,657, June 17, 1930. An apparatus for handling brick comprising a pallet for supporting a stack of brick, a cage to surround the stack, a hoisting head adapted to be suspended, grappling means carried by the cage for lifting the pallet, grappling means carried by the hoisting head for lifting the cage and thereby lifting the pallet, manually operable means carried by the hoisting head for operating the grappling means carried by the cage, and manually operable means carried by the hoisting head for operating the grappling means carried thereby.

Brick-mason tool. JOHN ADAM KAUFMAN. U. S. 1,764,106, June 17, 1930. In a mason tool of the class described, a handle, a shank rigidly mounted on the handle, and extending therefrom, a raking implement adjustably mounted on the outer end of the shank, guide rollers carried by the shank and located inwardly of the raking implement, the implement being disposed between the rollers, a shaft mounted on the intermediate portion of the shank, fastening means for the shaft, a runner carried by the lower end of the shaft, the runner functioning as a jointer and being provided with means for connection to the raking implement.

Hollow tile for building purposes. FRITZ KOCH. U. S. 1,764,798, June 17, 1930. A tile for building purposes comprising a rectangular body of hollow tubular shape having a wall adapted to be exposed on the exterior of a building structure and formed with longitudinally extending ribs upon the interior of the wall, the sides of the ribs being of reëntrant form to positively interlock with mortar applied to the ends of the tile.

Mechanical bricklayer device. ANNIBALE A. GUERINI. U. S. 1,764,836, June 17, 1930. In a mechanical bricklayer, a pattern divided into compartments shaped to receive the brick to be laid and suitably disposed to produce a staggered relation between the respective brick, and means for maintaining the pattern in horizontal position on a wall and against inadvertent movement in a direction perpendicular to the face of the wall, the means comprising a plurality of supporting projections carried by the pattern and arranged to extend into the joints between previously laid courses of brick to support the pattern in firm position directly upon an already built portion of the wall.

Brick-handling apparatus. GRAFTON E. LUCE. U. S. 1,765,765, June 24, 1930. A brick-handling fork comprising a support having a downwardly extending portion, a plurality of brick supporting fingers pivotally mounted on the lower end of the downwardly extending portion, a shaft extending from the lower end of the downwardly extending portion to the upper end thereof, a gear connection between the lower end of the shaft and the fingers, and means positioned in the upper portion of the support for locking the shaft against rotation for maintaining the fingers in supporting position and releasing the shaft so as to permit the free rotation thereof, whereby the fingers may freely swing about their pivotal mounting to dumping position.

Brickmaking machine. ROY P. M. DAVIS. U. S. 1,766,285, June 24, 1930. In a brickmaking machine, a sectional mold and support therefore, mold washing means positioned beneath the mold support, means for covering the top of the mold, and means for causing the washing means to discharge a washing fluid against the bottom of the covering means.

Brickmaking machine. ROY P. M. DAVIS. U. S. 1,766,286, June 24, 1930. A brickmaking machine comprising upper and lower pairs of horizontal mold tracks, a pair of vertical tracks adjacent each end of the horizontal tracks, an elevator confined between one of the pairs of vertical tracks for lowering the molds from the upper to the lower tracks, a combined elevator and stripper confined between the other of the pairs of vertical tracks for stripping the molds from the brick therein and elevating the molds from the lower to the upper tracks, means for transferring the molds from the elevators to the horizontal tracks and from the horizontal tracks to the elevators, and means for filling the molds, slicking the brick therein, and washing the molds in transit over the horizontal tracks.

Brick-wall construction. EDWIN M. WYATT. U. S. 1,768,651, July 1, 1930. In a brick-wall construction, the combination of bonding courses having as constituents thereof, stretcher brick with intervening flat laid header brick inwardly protruding, soldier brick interposed between the inwardly protruding header brick to constitute longitudinally separated vertical pilasters, and sufficient intervening stretcher courses to space the bonding courses a distance substantially equal to the height of the soldier brick.

Making porous concrete by forcing air into cement slurries. JOHN A. RICE. U. S. 1,769,275, July 1, 1930. A method of manufacturing porous concrete consisting in (1) preparing a cement slurry; (2) preparing separately a frothing compound; (3) mixing together the slurry and the frothing compounds in proportions of 100 to 60; (4) forcing a gas into the mixture; and (5) pouring the mixture into suitable molds to set and harden; the frothing compound comprising casein, water, and calcium hydrate.

Producing cellular cementitious material. JOHN A. RICE AND RICHARD B. RICE. U. S. 1,769,309, July 1, 1930. In a concrete mixer, a substantially cylindrical container for cement slurry, means for creating currents in axial direction of the container, and other means for creating centripetal currents therein; the other means comprising a perforated bottom in the container, a chamber for compressed gas co-extensive with the bottom, and suitable connection with the chamber from a source of compressed gas; a set of perforated cylinders of graded diameters mounted one within the other and interiorly of the first means, the cylinders being freely revoluble in the container.

Steam and clay mixing nozzle. EMMETT V. POSTON. U. S. 1,770,011, July 8, 1930. A steam and clay mixing nozzle comprising in coöperative combination a central discharge tube provided with an outer annular converging tapering surface at the discharge end, a steam jacket encompassing and detachably supporting the discharge tube, an adjustable sleeve within the jacket and adjustably coöperating with the outer tapering surface of the central discharge tube to define an annular tapering duct encircling the discharge mouth of the central discharge tube; the annular duct being of a cone frustrum formation whose apex is beyond the essential limits of the discharge end of the annular adjustable sleeve; means coöperating with the adjustable sleeve and jacket for preventing unnecessary escape of steam from the nozzle and means detachably connected with the jacket for feeding granular clay, etc., into the central discharge tube.

Molding brick, etc. D. G. MACKENZIE. Brit. 328,545, June 25, 1930. Comprises improved feed and delivery means for the machine described in Brit. 281,346, *Ceram. Abs.*, **7** [4], 233 (1928).

Refractories

Refractory materials. COLIN PRESSWOOD. *Blast Fur. Steel Plant*, **18** [5], 838–40 (1930); *Trans. Amer. Soc. Steel Treating*, **17** [6], 898 (1930); for abstract see *Ceram. Abs.*, **9** [5], 357 (1930). E.J.V.

Refractory materials. H. L. *Rev. mat. constr. trav. pub.*, No. 248, pp. 192–96

(1930).—The raw materials are described and the processes of manufacture are explained. A.J.M.

Refractories and their applications. MARTIN J. CONWAY. *Blast Fur. Steel Plant*, **18** [6], 1001–1003 (1930).—The term, "refractory materials," is used as an inclusive one for fire brick and shapes of various kinds whose chief characteristic is their ability to be used at high temperatures, but resistance to heat alone is by no means the only property which such materials are required to possess. It is slowly being recognized that the term refractory does not merely mean resistance to a high temperature but that, in practice, it must also include resistance to the abrasive action of the contents of the furnaces, dust in flue gases, corrosion due to chemical action of gases or other substances, sudden changes in temperature, and other possible causes of disintegration. It frequently happens that of two kinds of fire brick in use in a particular furnace, the most durable one will be the least refractory in the sense that it loses its shape at a lower temperature than the other. In such a case, a dense brick of fine texture may resist abrasion and corrosion far more effectively than another brick of a more porous nature though the latter may have a higher melting point. Users of refractory materials do not always realize that materials change in volume as the temperature changes. In the technical sense the term, "expansion," covers either an increase or a decrease in volume, the former being a positive expansion and the latter, a negative. Having reference to ordinary fire brick, it is common experience to find that, on cooling after heat treatment, they do not recover their original size. They show a permanent volume change and may be either larger or smaller than before. Thus arises the term of "permanent" or "after-expansion." The reasons for these phenomena are discussed. The greatest contribution to furnace design and refractory life in recent years has been the substitution of suspended refractory for the conventional sprung arch, and the adaptation of this type of construction to the side walls as well as the roofs and arches of all types of industrial and boiler furnaces. After enumeration of the disadvantages of the sprung arch, the following advantages of the flat arch are pointed out: (1) ease with which a worn-out tile can be replaced; (2) uniform distribution of heat; (3) greater span available; (4) increase in volume of furnace; (5) reduction in maintenance costs; (6) greatly improved combustion; and (7) greater durability of arch. Much has been learned about practical furnace construction since pulverized coal came into general use during the past few years and improvements are still going on. Illustrated. E.J.V.

Refractories for open-hearth furnaces. ANON. *Blast Fur. Steel Plant*, **18** [6], 999–1001 (1930).—When brick are used in the mats and foundations the quality of the work must be 100%, as the furnace must have a good foundation. Insulation of the flues is an important item on new construction and care should be taken to select an insulating brick that does not disintegrate with age. The checker chambers are usually built of a good grade of fire brick, and these should be used throughout the flues to the stack. Second quality brick are sometimes used in the lower parts of the chambers and flues, but where producer gas is used as a fuel, it might be considered false economy to use them. Insulating the checker chambers has become an important factor in fuel savings and $4^1/_2$-in. insulating brick should be installed against the steel jacket of chambers, under the floors, and over the top of crowns, as the heat loss is greater from the crowns than elsewhere. Opinions vary greatly in the matter of the size of checkers, salvage, heat penetration, and regeneration qualities. In some applications, Yough silica brick are being used in the checker chamber walls to a point 6 or 8 ft. below the spring of crowns, and also in the crowns. The fantail arches of furnaces should be installed with clay brick and covered well to protect the refractories from water leaks and heavy material dropping on them. Silica brick should be used to support the fantails, since the cutting effect of the outgoing flame fluxes a clay brick, and reduces the

life of the furnace. The design of slag pockets has a great deal to do with the life of the furnace, and the efficiency of operation. In the walls of these pockets clay brick are generally used to about the height of the slag line, and silica brick from this point up to the roof of the furnace. Chrome brick are being used to a great extent in gas-port linings and if installed properly will last the life of the furnace. Many types of furnace bottoms have been installed and good and bad runs recorded, but to get the actual cost of installation and records of the runs has been almost impossible to date. The old magnesite brick bottom with a monolithic lining of magnesite fired in on top of it has been replaced with a bottom mostly of clay brick, racked back to suit the slope of the bottom, and lined with 9 in. of magnesite brick to a point below the fore plate where all magnesite brick are used. When the furnace was brought up to temperature, the bottom was dusted with fine slag and magnesite and all expansion joints filled and the bottom was fired in layer by layer to the proper height and shape. In the last 10 years chrome brick have replaced magnesite brick for bottoms, though many manufacturers use magnesite brick bottoms. Open-hearth crowns in most plants do not run the full life of the furnace and especially not in producer and natural-gas furnaces. E.J.V.

Increasing life of furnace brickwork. ANON. *Blast Fur. Steel Plant*, **18** [6], 1011–12 (1930).—Brick for furnace use are made from a refractory material mined from the ground, pulverized, and mixed with a bonding material, shaped, and heat treated in a kiln. A certain portion of the brickbat pile resulting from dismantling a furnace is a better source of refractory material than most brick manufacturers possess, because some of the unglazed material in the bats has received a wonderful heat treatment during its several months service in a furnace wall and most of the expansion has been fired out of it. All that is needed to prepare it for further service is to select the clean bats, again pulverize it, and mix it with some bonding material, and it is ready to place back on the furnace wall. The prepared material does not have to be made into shapes and kiln dried, but can be mixed with water and placed on partially fired-out furnace linings and let the furnace heat give it the further heat treatment needed. The quickest and most effective way of applying such material is by shooting it on furnace linings with a cement gun. In the scheme of applying a ground brickbat mixture to furnace walls, the factor that requires the most careful experimentation is the constituency of the mixture to be used in various types of furnaces and in various types of conditions in furnaces. Some different batches and their applications are discussed. Another factor in effective work that comes with experience, is the skill of the gun operator. The rate at which this method of lowering refractory cost has spread throughout the steel industry in the past 8 years is an indication of the results it is achieving and the interest shown in the results indicates a future wider application. E.J.V.

Refractory linings in cement kilns. ALFRED MÜLLER. *Rev. mat. constr. trav. pub.*, No. 247, pp. 133–36 (1930); for abstract see *Ceram. Abs.*, **9** [7], 538 (1930). A.J.M.

Silica refractories for coke ovens. RICHARD RICHARDS. *Queensland Govt. Mining Jour.*, **31**, 162–63 (1930).—For practical purposes the capacity of a refractory to remain rigid under load at a high temperature becomes a deciding factor. The high softening point under load possessed by silica refractories places them in a position unapproached even by the best fireclay products. The life of a siliceous fireclay refractory in ovens carbonizing very salty coals is uncertain. Salt vapors do not, however, affect silica refractories, and after lengthy service in contact with salty coals they show no sign of corrosion. Although the mechanical strength of fireclay refractories when cold is highly satisfactory the behavior of the refractory when operating under conditions of structural pressure and high temperatures is inferior to silica. To remove all risk of failure the refractory should possess definite properties and values. The raw materials must possess a high degree of purity. Only rocks (quartzites) having their silica grains so completely

bonded and enveloped with siliceous cement are suitable. Mica is a particularly deleterious mineral. The commonest impurities of suitable rocks are feldspars and oxides of iron, with the alkalis and alkaline earths as subordinate ingredients. Whether crystalline or cement quartzites are used, toughness and mechanical strength are essential features. Rocks which crumble easily are not to be recommended. Typical analyses of some high-grade quartzites are given in a table. See also *Ceram. Abs.*, **9** [3], 199 (1930).

E.P.R.

Study of checker brick. R. M. KING. *Blast Fur. Steel Plant*, **18** [5], 837–88 (1930); *Brick Clay Rec.*, **76** [12], 771 (1930); see also *Ceram. Abs.*, **9** [3], 192 (1930). E.J.V.

Glass-house refractories. Study of corrosion-resisting properties. J. H. PARTRIDGE AND H. C. BIGGS. *Jour. Soc. Glass Tech.*, **14** [53], 63–84 (1930).—The method used to determine the corrosion-resisting properties was to immerse test samples for three hours in a mixture of 3 parts 50 to 60% HF solution and 2 parts concentrated H_2SO_4, which is heated to about 100° by placing it in boiling water. The specimens, of equal size, were held in lead vessels fitted with condensers. After the acid treatment the specimens were washed and the film of gelatinous silica was removed by boiling for 1 hr. in 1:1 H_2SO_4, and then washed for 1 hr. in running water, and dried at 110°. The loss in weight was then obtained. This test is now a part of laboratory routine tests for tank blocks. The test on sillimanite blocks showed that (1) when used under standard conditions it gives results which are of value in judging the probable behavior of tank blocks under service conditions; (2) the test should be repeated on a sample which has been refired to a temperature slightly in excess of the maximum working temperature. Accurate true porosity measurements should be taken into consideration when comparing results; (3) temperature of firing and choice of bonding material are of great importance if sillimanite is to give satisfaction in service. Factors which may be of assistance in the choice of blocks for use in glassmelting furnaces are as follows: (1) the higher the alumina content the greater the resistance to corrosion; (2) true porosity should be low, not more than 20%; loss in weight after the acid corrosion test should not exceed 25%; (3) physical structure is important; blocks should have fine, close uniform texture, free from iron spots, and open pores; (4) blocks should be fired to as high a temperature as possible, consistent with the nature of the clay. The acid corrosion test alone does not differentiate readily between different pot-clay mixtures. Resistance of pot-clay is less than that of good tank blocks. Specimens prepared by adding calcined silica or alumina to raw clay, showed that the higher the Al_2O_3 content the greater was the resistance to corrosion. The tests were repeated using ball clay in place of raw clay and again the higher the Al_2O_3 the greater was the resistance to corrosion.

G.R.S.

Evolution of tank block manufacture. H. HIRSCH. *Glastech. Ber.*, **7** [11], 497–510 (1930); *Diamant*, **51** [35], 683 (1929).—Through mechanization and increasing performance in the glass industry the refractory blocks, of which the glass tanks and especially the side walls are built, are required to be much stronger than formerly. The producers of refractory materials have investigated this situation through the production of newly calculated block forms, the testing of which requires a long time due to the manifoldness of attacking circumstances, thus making the formation of a uniform judgment difficult. The corrosion phenomena which take place and the requirements developed as a result thereof on a useful tank block are discussed. The evolution of the production is followed, from the primitive starting methods through the manufacture of blocks by each glasshouse for its own consumption and then to the point according to which it is possible to improve the block properties, to obtain them more homogeneous, stronger, and denser. The influence of the chemical composition, separate clayey raw materials, and the evolution of high alumina up to the newer so-called mullite bodies, are discussed.

Of the forming processes, the hand forming, production of cast block from slip clay body, S.u.G. process, and the casting of molten mullite bodies are taken up in order. For purposes of comparison a number of characteristic tank blocks of different compositions and made by different methods were tested and the data are presented. The results of an inquiry into the preservation of glass tank blocks in service are given. Illustrated. E.J.V.

Refractory-maintenance cements in nonferrous foundry. H. E. WHITE. *Brass World*, **26** [5], 119 (1930).—(Presented at the Technical Session of the Foundrymen's Assn., Cleveland, May, 1930.) The desired properties of refractory cements are elasticity, mechanical strength, high softening point, resistance to abrasion, low shrinkage, resistance to disintegration, slagging and spalling, long vitrification range, and workability. Specifications, if furnished, would be of assistance in securing proper material; data for such specifications are given. Some 49 different brands of cement were studied in the preparation of this report. These are discussed under such groups as fireclay-silica ganister, silicon-carbide, alumina and alumina-silica, and kaolin-clay combinations. Data secured in 1926 and 1929 are compared, and these show that the so-called super-refractories are on the increase. Application of the different cements to various uses is discussed. E.P.R.

Relation between physical properties of fire-resistant building materials and process of manufacture. W. GROOTHOFF. *Pit and Quarry*, **19** [2], 37–40 (1929); for abstract see *Ceram. Abs.*, **8** [12], 892 (1929). E.P.R.

Comparison of properties and industrial durability of lime-bonded and clay-bonded silica brick. W. J. REES. *Sprechsaal*, **63** [22], 410 (1930); for abstract see *Ceram. Abs.*, **8** [11], 814 (1929). M.V.K.

Silicon carbide and mullite. HAROLD E. WHITE. *Blast Fur. Steel Plant*, **18** [5], 840–42 (1930).—Silicon-carbide refractories are noted for their high thermal conductivity. A silicon-carbide refractory will transmit heat seven times faster than the same tile made from ordinary fire clay. This refractory also withstands extreme temperatures far in excess of any fireclay refractories. Silicon carbide, however, has the same faults that crystalline alumina has, in that there are certain metal oxides and slags which attack it. The mineral itself has no melting point but when a temperature of 4150°F is reached, it is converted into silicon vapor and graphitic carbon. In 1916, it was discovered that a mineral termed mullite present in most ceramic ware was largely responsible for the mechanical strength of these articles. While still in the developmental state it has shown remarkable characteristics not found in other similar clay minerals and which have a distinct application. Its resistance to slag attack has made it a welcome addition to the other two refractory minerals. While its melting point is slightly below 3300°F, which is just a few hundred degrees higher than fireclay refractories, its resistance to solution by metal oxides and slag minerals is so much greater that it promises to be of wide usage. Crystalline mullite may be prepared by fusing mixtures containing appreciable amounts of alumina, such as china clay, fire clay, and bauxite, in the electric furnace. When alumina is less than 68%, crystalline mullite with glass is produced. This type is not very resistant to loads at high temperatures because of the early fusion and internal lubricating action of the glass surrounding the crystals. Above 68% alumina, crystalline corundum appears and the glass is practically absent. This latter composition is resistant to high-temperature loads when an interlocking, recrystallized bond is developed. This high alumina material is not affected materially by acid slags, but is not resistant to basic slags. The dense structure of a brick of material above 68% Al_2O_3, however, causes less slagging than silica brick. Carefully made mullite-corundum brick withstand higher physical tests than the same silica, magnesia, chrome, fireclay, or zirconia brick. The largest field for mullite refractories has been

found in the glass industry where it has always been difficult to hold molten glass in fireclay containers. E.J.V.

Silica refractories. GEORGE KNOX. *Foundry Trade Jour.*, **42** [698], 13 (1930); for abstract see *Ceram. Abs.*, **9** [4], 286 (1930). H.W.A.

New aluminite insulation product. ANON. *Glass Ind.*, **11** [7], 165 (1930); *Power*, **71** [25], 1004 (1930); for abstract see *Ceram. Abs.*, **9** [8], 646 (1930). E.J.V.

High-alumina refractories replacing plain fire brick in industry. ANON. *Pit and Quarry*, **20** [7], 54 (1930).—This development of evolution in the industrial processes has brought about more severe operating conditions in the various types of furnaces employed. The limit to which the furnace can be driven with economy is determined by the refractory lining. In many parts of furnaces, where the requirements are severe, high-alumina refractories have supplanted fireclay brick, silica brick, and even some of the more costly refractories, to decided advantage. The higher refractoriness of high-alumina brick permits a greater degree of insulation than is practicable with fireclay refractories. The alumina-silica system is interesting in any consideration of alumina refractories. While the chemical composition may indicate approximately the ultimate fusion point, it does not reveal the mineral constitution, upon which depend many desirable qualities, or serve as a definite guide to all of the physical properties of a brick. The properties of mechanical strength at high temperatures, shrinkage, or expansion under heat, slag resistance, porosity, and permeability are dependent upon such factors as method and temperature of calcination of the constituents, bonding materials, process of manufacture, texture or fineness of grind, and firing temperature. E.P.R.

Preparation of alumina from volcanic ash. ISAMU SEKI. *Pit and Quarry*, **18** [13], 113 (1929); for abstract see *Ceram. Abs.*, **8** [12], 895 (1929). E.P.R.

Resistant crucibles for silicate melts. WALTER KRINGS AND HERMANN SALMANG. *Z. angew. Chem.*, **43** [18], 364–66 (1930).—Crucibles of Al_2O_3, Zr_2O_3, and $MgO \cdot Al_2O_3$ were fired just below their melting points to a dense mass. Reactive silicate melts were then placed in the crucibles and heated to 1550°C for five minutes. The crucibles were then removed and examined. Very little reaction was observed between the crucible and melt due to the dense structure of the former. Hence the authors conclude that the nonresistant properties of such crucible materials are rather due to their physical properties than to their chemical reactivity with the melt. L.T.B.

Thermal expansions of fused alumina, bauxite, and diaspore. ANON. Bur. Stand., *Tech. News Bull.*, No. 158, pp. 55–56 (1930).—Among the refractory materials included in an investigation of the linear thermal expansion of special refractories from atmospheric temperature to 1800°C are samples of fused alumina (artificial corundum), bauxite containing approximately 80% alumina (water-free basis), and diaspore of the grade used in the manufacture of refractories. The data obtained cover two heat treatments. Corundum when tested as received from manufacturer who prepared the specimen, had a maximum expansion of 1.13% at 1480°C; after heating to 1800°C twice, the maximum expansion was 1.49% obtained at 1750°C. Average coefficient from 20 to 1750°C was 8.6×10^{-6}. The specimen of bauxite fired for 5 hrs. at 1400°C gave a maximum expansion of 0.72% at 1100°C; after heating to 1675°C, the maximum expansion, 1.38%, was obtained at 1300°C. The average coefficient from 20 to 1300°C was 8.1×10^{-6}. Diaspore after heating to 1575°C showed its maximum expansion, 0.99%, at 1280°C. After heating to 1730°C, the maximum expansion, 1.18%, was obtained at 1580°C. Average coefficient from 20 to 1580°C is 7.6×10^{-6}. R.A.H.

Purification of bauxite. ANON. *Engineering*, **129** [3355], 571 (1930).—Ordinary washing and gravity concentration of bauxite on tables, jigs, etc., is difficult because the required products and the undesirable gangue differ little in density; the specific gravity

ranges from 2.4 for gibbsite to 2.6 for quartz and kaolinite. Moreover, the mixture of constituents is mostly very intimate so that fine grinding of the material is required, which is costly. Some iron can be removed by tabling and jigging; another way is to roast the mineral in reducing atmosphere and remove Fe_3O_4 by magnetic separation. Flotation experiments appear to be promising in the absence of slimes. By removing one of the impurities, inferior grade of bauxite may be made suitable for special purpose. In connection with this, the work of B. W. Gandrud and F. D. de Vaney on "Bauxite, Float-and-Sink Fractionations and Flotation Experiments" (see *Ceram. Abs.*, **9** [6], 439 (1930)) is discussed. A.A.

Researches on use of sillimanite as material for arches. FRANZ SOMMER. *Stahl Eisen*, **50** [23], 804–806 (1930).—As the ratio of the price of sillimanite to that of silica is about 4:1, and the durability stands as 1:1, the investigations on the use of sillimanite as material in kiln arches were discontinued. No justification for the substitution of sillimanite blocks was found. M.V.K.

Preventing pressure cracks in dry-press refractories. G. A. BOLE. *Blast Fur. Steel Plant*, **18** [6], 1012 (1930).—A review is made of the work on dry-press refractories conducted by R. E. Birch. See also *Ceram. Abs.*, **9** [6], 439 (1930). E.J.V.

Furnace insulation in the steel mill. E. A. PHOENIX. *Blast Fur. Steel Plant*, **18** [6], 1005–10 (1930).—Heat flow through the refractory walls of furnaces, flues, and other heated equipment carries a large percentage of the heat to the outside surface, from which it is lost into the atmosphere by radiation and convection. The use of these higher temperatures in industrial processes would have increased heat losses very greatly, were it not for the fact that heat-insulating materials have been developed which can be used at these higher temperatures. In the high-temperature field, the insulating material must not only have a low conductivity but must also have a high degree of refractoriness, a quality not ordinarily found in insulating materials. Diatomaceous silica, due to its high degree of refractoriness, forms the base for practically every high-temperature insulating material in use today. Being practically pure silica, the material has a very high melting point, 2930°F. The high insulating value of diatomaceous silica products is due to the minute cellular structure of the material, which effectively breaks up the heat waves. Diatomaceous silica is produced in a wide variety of forms for insulating purposes, some of which are listed. Insulation of various different forms of furnaces, etc., used in steel mills is described. Illustrated. E.J.V.

Interlocking suspended furnace arch. W. J. SHANE. *Blast Fur. Steel Plant*, **18** [6], 1013–14 (1930).—A new arch which possesses several novel features and which, before being placed on the market, was subjected to severe service for a long period, is that known as the Longenecker arch. Due to the interlocking design of the tile and cantilever method of suspension, spalling troubles and premature roof failures are negligible. The Longenecker arch makes use of an interlocking tile, which has on one of its faces an inverted V-shaped tongue of approximately $^3/_8$ in. thickness and on the opposite face a similar shaped groove. The purpose of this tongue and groove is to furnish a positive interlock which will hold any broken inner tile ends from dropping out. Each tile is equipped with a hanger casting of a modified U-design. This hanger, when held in a forward tilted position, freely slips over the top of the tile and allows the T-hanger end to drop into the T-slot of the tile which is located directly above the tongue. Then as the hanger is moved back into an upright position the short leg of the U-casting makes contact on the groove side of the tile. In this position the hanger engages the tile and serves as a handle by which the tile can be lifted. The tile are suspended directly from the lower flange of an I-beam in bundles of 12 by means of the special "thumb and finger" type beam casting. The cantilever type suspension causes each tile to face tightly against the adjacent tile due to the suspended weight being supported off center. This

assures a positive sealing of all vertical joints which enclose the hanger casting embedded in the tile and hidden back of the tongue which serves as a baffle, further protecting the casting from the inside furnace temperatures. It is claimed that this type hanger casting is practically self-cooling. The same type tile and hanger castings are used to form the suspended side wall or curtain wall. The tongue and groove in this case interlocks all horizontal joints and in addition supports the tile against any inward tilting load. A special interlocked slope tile is used where it is necessary to change the contour of the arch into a sloping position. Illustrated. E.J.V.

Care and maintenance of fuel-fired furnace linings in nonferrous foundry. H. E. WHITE. *Brass World*, **26** [5], 118–19 (1930.) (Presented at the Technical Session of the Foundrymen's Assn., Cleveland, May, 1930.) The discussion of refractories is divided into two sections: one on the open-flame furnaces and one on the nonferrous melting cupola. The open-flame furnaces are listed as (1) vertical barrel type, nonrotating, (2) horizontal barrel type, rotating, and (3) egg-shaped tilting type. Data secured in 1926 and 1929 surveys are compared; these show a decrease in use of fireclay refractories and an increase in silicon-carbide and the alumina-silica, mullite and aluminium-oxide types. Causes for failure are analyzed. While these causes are numerous, spalling and improper furnace atmospheres are two of the most important. Types of available lining materials are listed and discussed. Proper installation is stressed, drying and glazing being of special importance. Factors conducive to long life are listed as follows: proper installation, thorough preheating, proper glazing before using, daily inspection, hot patching when needed, weekly cold patching, and use of mild cleaner to remove accumulated slag. E.P.R.

Effect of continued remelting of cullet in sillimanite and fireclay vessels. A. A. CHILDS, V. DIMBLEBY, H. W. HOWES, AND W. E. S. TURNER. *Glastech. Ber.*, **7** [11], 511–14 (1930); for abstract see *Ceram. Abs.*, **9** [7], 534 (1930). E.J.V.

Rapid method for determination of moisture in grog pastes. KARL MOHR. *Tonind.-Ztg.*, **54** [36], 611–12 (1930).—M. describes a new method for the determination of moisture in grog pastes, and his own test in which 20 g. of a grog paste dried in exactly one hour. The same quantity of paste would lose only 10% of its moisture with other methods. M.V.K.

Mathematical valuations of joint experiments on resistance to pressure of fire brick. VLADIMIR SKOLA. *Tonind.-Ztg.*, **54** [37], 624–26 (1930); for abstract see *Ceram. Abs.*, **8** [12], 928 (1929). M.V.K.

Corrosion of crucibles by iron. M. A. BESBORODOV, M. F. SHOOR, AND I. I. MOGEIKO. *Ceramics and Glass*, **6** [1], 11–19 (1930).—The authors discuss the origin of iron found in crucibles used for fusing glass and its influence on glass batches, as well as methods of repairing the holes in these crucibles. M.V.K.

Flow of gas in blast-furnace shaft. S. P. KINNEY. *Fuel Sci. Practice*, **9** [3], 114–20 (1930). R.G.M.

New method for surface protection of steam generators and their furnaces. E. PIERNET. *Rev. gén. élec.*, **26**, 625–27 (1929).—Results obtained by methodic exploitation of the refractory materials, Neutron and Stopair, are given. See also *Ceram. Abs.*, **9** [5], 389 (1930). (*C.A.*)

Brickwork and ventilation. L. M. WILSON. *Fuel Sci. Practice*, **8** [10], 469 (1929).—W. describes the action of temperature on silica roof brick in a furnace and advocates the use of proper ventilation of the cold end of the brick. R.G.M.

Bonding strength of firebrick mortars. C. C. WEEKS. *Can. Chem. Met.*, **14** [6], 22 (1930).—A brief generalization on the bonding materials used at the present time for high temperature and refractory installations is given. A simple method for testing such materials, using standard molding and tensile equipment was outlined. It has

been found that wet high-temperature cements produce a great deal better bond than dry high-temperature cements or fire clays; that dry high-temperature cements produce a more constant and reliable bond than fire clays, and that both types of high-temperature cements produce bonds over a much longer temperature range than fire clays. Fire clays produce doubtful and short temperature range bonds in fire brick. Tests and bond strength on samples of several types of refractory cements, run over a 2400°F temperature range, were presented, allowing a comparison of the bonding range and bonding strength of representative commercial fire clays, dry high-temperature cements, and wet high-temperature cements. E.J.V.

Refractory mortars. PHILLIP. *Refrac. Jour.*, **5** [57], 352 (1930); for abstract see *Ceram. Abs.*, **9** [7], 536 (1930). E.P.R.

Plastic cement. ANON. *The Foundry*, **58** [3], 132 (1930).—A new high-temperature cement has been developed. Its trade name will be Adachrome Plastic Cement. The cement has a chromite base and is claimed to be chemically inert, hard, dense, and highly refractory. It is said to be resistant to acid and basic slags, molten metal penetration, abrasion, erosion, and chemical reaction in the burning of acid sludge. It may also be used as a coating material and as a binder for patching materials. H.W.A.

Refractories in cement industry. K. ENDELL. *Refrac. Jour.*, **5** [57], 352 (1930); for abstract see *Ceram. Abs.*, **9** [7], 535 (1930). E.P.R.

Study of equilibrium of refractory roofs. R. HUSTIN. *Trans. Amer. Soc. Steel Treating*, **18** [1], 121 (1930); for abstract see *Ceram. Abs.*, **9** [7], 538 (1930). E.P.R.

Grog material of high basicity. ANON. *Tonind.-Ztg.*, **54** [43], 721–22 (1930).—Only the raw products, bauxite, hydrate of alumina, and alumina, can be used for making genuine, basic (containing excess alumina), refractory fire brick. Both hydrate of alumina and alumina would be ideal raw materials except that they shrink greatly when fired, while hydrate of alumina is expensive. "Pyralumite blocks," a specially prepared form of the hydrate of alumina, is described. A method of removing the Fe_2O_3 content of bauxite at low cost will soon be patented which will make bauxite the ideal raw material for a high basic grog material, mechanically hard, infusible, and insensitive to temperature change. M.V.K.

Tests with refractory blocks in electric kiln arches. OTTO KUKLA. *Stahl Eisen*, **50** [23], 800–803 (1930).—The following results were obtained: Silicon carbide lasts well in reducing atmosphere as roofing material in kilns which are charged cold. Silicate blocks, however, still show the best results. Corundum on account of its tendency to spall cannot be used. M.V.K.

Trade marks in refractory and furnace construction industries. III. ANON. *Feuerfest*, **6** [5], 67–70 (1930).—Trade names of various refractories and furnace parts with the names and addresses of the manufacturers are given. For Part II see *Ceram. Abs.*, **9** [4], 287 (1930). L.T.B.

Three puggings make denser product. ANON. *Brick Clay Rec.*, **76** [12], 770 (1930).—The Buckeye Clay Pot Co. of Toledo, Ohio, is making a block by pugging the body three times after it has been tempered in a wet pan. It was found that blocks made the new way were heavier than the others, regardless of whether vacuum was used or not. The procedure followed is described. Illustrated. E.J.V.

Chrome cement for laying brick. ANON. *Blast Fur. Steel Plant*, **18** [7], 1189 (1930).—A survey made by the A. C. Nielsen Co. on the use of a high-strength multibond chrome ore base cement, used in laying up fire brick at the plant of the Camden Forge Co., Camden, N. J., is given. The applications include hearths in 7-car type annealing furnaces and one nitriding furnace and furnace walls and arches in four steam boilers, two of which burn pulverized fuel. E.J.V.

Refractories discussed by British technologists. ANON. *Nat. Glass Budget*, **45** [51], 14 (1930); for review see *Ceram. Abs.*, **9** [6], 209 (1930). E.P.R.

Fire clay discovery near Dudley. ANON. *Refrac. Jour.*, **5** [57], 310 (1930).—An estimate of 7,000,000 T. of valuable fire clay has been added to the mineral resources of South Staffordshire as the result of a discovery. The exhaustion of the seams that have been conclusively proved would with an output of 1500 T. a week, occupy a period of approximately 100 yrs. Five seams of the valuable mineral have been proved, varying in thickness from 3 to 11 ft. E.P.R.

Economic position of fireclay industry in upper Franconia during first quarter of 1929. ANON. *Feuerfest*, **6** [5], 74–75 (1930). L.T.B.

Zirconia. ANON. *Refrac. Jour.*, **5** [57], 352 (1930).—The use of oxide of zirconium for refractory brick has been hampered by two circumstances: (1) its high price, due not to any scarcity of the oxide but to the difficulty of extracting it from its ores, and (2) its tendency to crack. The first of these difficulties has been overcome by the German Welsbach Co. which has two new processes; the second has been overcome by dissolving minimum quantities of magnesia or of lime in the zirconia. The working up into brick has also been greatly simplified and improved. E.P.R.

Fusion and preparation of grog blocks for glass kilns. P. P. BUDNIKOFF, S. A. SCHICHAREVITSCH, AND I. G. SCHACHNOVITSCH. *Ceramics and Glass*, **6** [1], 21–27 (1930).—The authors describe tests made on grog blocks prepared from clays of Tchassoff-Jar. The blocks obtained were found satisfactory. See following abstract. M.V.K.

Molding refractory objects made of half-dry pastes. P. P. BUDNIKOFF, S. A. SCHICHAREVITSCH, AND I. G. SCHACHNOVITSCH. *Ceramics and Glass*, **6** [2], 81–84 (1930).—The authors describe tests made with clays from Tchassoff-Jar, the composition of which is given. The results obtained were as follows: (1) a dry method of molding can be used for preparing grog blocks for kilns; (2) the quantity of grog is about 70%, 15% thin clay, and 15% binding clay diluted by a suitable electrolyte; (3) the time of drying with such a paste is 6 to 10 days instead of 3 to $3^1/_2$ months; and (4) this paste can be used for preparing fire brick which can be fired immediately after their preparation. See also *Ceram. Abs.*, **9** [8], 675 (1930). M.V.K.

BOOKS AND PAMPHLETS

Activities of Ukraine Technical Research Institute for Silica Industries. (Arbeiten des Ukrainischen wissenschaftlichen Forschungs-Instituts für Silikaindustrie.) Vol. II. Published by Verlag der wissenschaftlich-technischen Verwaltung des WSNCh der USSR, Charkow. *Feuerfest*, **6** [5], 60 (1930).—One section of this report is concerned with the conversion of quartz to tridymite. Quartzite from Jassinowataja was used for this purpose. This quartzite is extremely difficult to convert to tridymite. At 1410°C the conversion is not very great. On refiring the sample at 1460° better results were obtained, especially if other minerals were present such as phosphorites, etc. These quartzites are not of great value for the manufacture of silica refractories. L.T.B.

Knowledge of ceramic properties of lime-alumina silicates and other refractory and high refractory materials. E. BERL AND FR. LÖBLEIN. VDI ed., Berlin, 1930. Rm 5. Reviewed in *Sprechsaal*, **63** [24], 456 (1930); *Feuerfest*, **6** [5], 78 (1930); see *Ceram. Abs.*, **9** [8], 652 (1930). M.V.K.

Formulas useful in calculating brickwork. ANON. *Blast Fur. Steel Plant*, **18** [7], 1186–87 (1930).—Reprinted from Harbison-Walker Refractories Co.'s "Modern Refractory Practice." Data and formulas useful in arch calculations are given. E.J.V.

Strong joints and longer life brick. ANON. *Pit and Quarry*, **19** [2], 105 (1929).—

Harbison-Walker Refractories Co. has published a 12-pp. pamphlet describing and illustrating the use of Firebond, a refractory cement. E.P.R.

Refractories. SEABOARD REFRACTORIES CO. *Brick Clay Rec.*, **77** [1], 50 (1930).—This booklet illustrates and describes high heat-resisting products. In addition to other data, the sizes of the various products are given. Some information about fire brick is included and on the inside back cover is published a handy table giving fusing points of Seger cones. E.J.V.

Corundite Refractories. CORUNDITE REFRACTORIES, INC. *Brick Clay Rec.*, **77** [1], 50 (1930).—A booklet describing in detail the company's products has just been published. Besides standard shapes and sizes, the booklet illustrates and describes muffle bottoms and tile, pyrometer protection tubes, electric furnace linings, crucibles, and many other products. It also gives tabular data covering various types and varieties of fire brick and shapes which will be helpful to the ceramic manufacturer in calculating his refractory requirements. E.J.V.

Refractory Products. ROBERT LEDUC. *Brit. Clayworker*, **39** [458], 117 (1930); *Feuerfest*, **6** [5], 78 (1930); for abstract see *Ceram. Abs.*, **9** [8], 652 (1930). R.A.H.

PATENTS

Refractory product. SANFORD S. COLE. U. S. 1,763,882, June 17, 1930. A refractory product containing a refractory base material and a cyanide compound of iron in admixture therewith.

Repairing furnace linings. JOHN E. ANDERSON. U. S. 1,765,558, June 24, 1930. A method of repairing a furnace wall construction consisting in removing the defective or damaged portion of the construction to form an opening for reception of a patch, securing anchor members in position to extend into the opening, and then filling the opening with plastic material forming a monolithic patch, the anchor members being enclosed by and embedded in the patch.

Brick-grinding machine. ARTHUR JONES. U. S. 1,767,136, June 24, 1930. The combination with a grinding wheel of a rotating and tilting table, a three-point brick support on the table, a gage frame having adjustable gage points on both sides and one end for positioning the brick on the support, and means for clamping a brick on the support.

Furnace-wall construction. FRANK I. SHEAHAN. U. S. 1,767,406, June 24, 1930. As an article of manufacture, a polyhedral furnace-wall refractory having parallel side faces, a bottom face perpendicular thereto and an end face perpendicular to the bottom and side faces and a top face portion parallel to the bottom face, the refractory being provided on its upper side with a transversely extending offset portion extending upwardly from the top face portion and in its bottom with a transverse groove extending perpendicularly to the side faces and disposed near the end of the refractory opposite the end face.

Replacing checker brick. BANKS D. BROWN. U. S. 1,767,832, June 24, 1930. In a regenerative glass furnace, the combination of checker chambers associated therewith, passages leading from the chambers to the furnace whereby certain of the chambers may be used to preheat the incoming gases and other chambers may receive the exhaust gases and absorb heat therefrom, removable portions in the side wall of the checker chambers beneath the passages, segregated portions of checker work adjacent thereto, whereby the portions may be removed and the segregated portions of worn checker work removed from the chambers as a unit without shutting down the furnace.

Making clay compound. THOMAS S. CURTIS. U. S. 1,768,545, July 1, 1930. The process of making a ceramic composition for increasing the strength of clay products, comprising the combining with clay, of pyrophyllite, the latter being first subjected to

heat treatment under reducing conditions, then cooled in a manner to prevent reoxidation, and crushed to assume a finely-divided state.

Furnace wall. LEE M. BEALL. U. S. 1,768,732, July 1, 1930. In a structure of the character described including a vertical support and a wall including horizontal sections, wall-retaining means including a series of tapering blocks spacing the sections, tapering filler blocks spacing the locking blocks and anchored thereby, a selected filler block being provided with a socket, and a retainer engageable in the socket and connected with the support.

Refractory mixture. JAMES M. LAMBIE AND DONALD W. ROSS. U. S. 1,769,297, July 1, 1930. A batch mixture for forming refractory bodies, containing an aluminous material that will expand at relatively low firing temperatures and a second aluminous material that will cause expansion at high temperatures, the mixture also containing silica, the materials being in quantities sufficient to counteract shrinkage of various ingredients during firing.

Composite refractory brick. JOHN D. MORGAN. U. S. 1,769,708, July 1, 1930. A furnace wall having a layer of highly refractory substantially constant volume, zirconium compound upon a body portion of refractory non-conducting material.

Silica crucible. WILLIAM H. JONES. U. S. 1,769,841, July 1, 1930. A silica crucible of the Gooch type comprising a tubular member provided at one end thereof with a lattice work of silica rods.

Sectional furnace wall. DAVID S. JACOBUS. U. S. 1,769,924, July 8, 1930. An inclined furnace wall having a plurality of fixed supports inclined to the vertical, horizontal supporting members connected to the upwardly disposed faces of the fixed supports, tile-supporting plates each having its lower edge resting on one of the horizontal supporting members and its upper part resting by gravity against another horizontal supporting member, whereby each of the plates is held by gravity in an inclined position against the horizontal supporting members, and tile on the inner face of each of the plates, with the lowermost tile on each plate supported on one of the horizontal supporting members.

New refractory. E. T. THIBAULT AND E. D. P. DEBURGRAEVE. Fr. 668,865, Feb. 1, 1930. *Refrac. Jour.*, **5** [57], 352 (1930); for abstract see *Ceram. Abs.*, **9** [6], 442 (1930). E.P.R.

Ceramic products. A C SPARK PLUG CO. Fr. 677,938, July 5, 1929. Refractory materials utilizable in the manufacture of ceramic products are made by melting an Al silicate in the presence of a flux, then submitting the molten mass to a sudden cooling to obtain the Al silicate in an unstable crystalline form. Fr. 677,939 describes the manufacture of ceramic materials from a plastic material such as clay with a non-plastic material such as the Al silicate of Fr. 677,938. See also *Ceram. Abs.*, **8** [11], 822 (1929). (*C.A.*)

Articles containing graphite. PATENT-TREUHAND-GES. FÜR ELEK. GLÜHLAMPEN M. B. H. (Karl Schröter and Marcello Pirani, inventors). Ger. 496,322, Feb. 24, 1929. Carbides, *e.g.*, SiC, are compressed at their dissociation temperature. (*C.A.*)

Melting quartz. SOC. QUARTZ & SILICE. Ger. 496,400, Dec. 15, 1927. In melting quartz in an oxidizing atmosphere by means of an electrically heated C rod embedded in the charge, the oxidizing atmosphere is produced by circulating air through the charge or by addition of H_2O. (*C.A.*)

Terra Cotta

Use of stoneware. FELIX SINGER. *Chem. App.*, **16**, 130 (1929).—S. discusses the use of stoneware in the chemical industry. See following abstract. (*C.A.*)

Uses of stoneware in machines and apparatus. FELIX SINGER. *Eng. Progress*,

10, 291–94 (1929).—Use of stoneware in machinery is particularly interesting because of its capacity to resist corroding effect of all acid gases and liquids, its great density, extraordinary mechanical strength, and ability to remain readily workable after firing. See also *Ceram. Abs.*, **9** [3], 205 (1930). (*C.A.*)

Manufacture of stoneware. T. W. TALWALKAR. *Jour. Indian Ceram. Soc.*, **2,** 21 (1930).—The development of acid-jar industry in India, a list of present leading manufacturers, scope of expansion and factors to be taken into consideration for the location of factories, are discussed. The cost of manufacture is also taken up. A.A.

Life of skyscrapers. ANON. *Arch. & Bldg.*, **62** [5], 155–56 (1930).—When the Tacoma Bldg., America's first skyscraper was demolished a thorough report on its condition was prepared by the committee of the Illinois Society of Architects. The tile arches of the floors were in good condition, while many of the marble stair treads had been worn to half of their original thickness. The brick walls were in general good condition. There were some spots in the parapet walls where the lime water had disintegrated and the brick became loosened. The interior load-bearing walls were quite solid, but on the outside walls the bond between the mortar and the brick was only fair. The terra cotta used was a reddish clay without slip or glaze and was set in a red lime mortar. Very little spalling of the surface was observed. The ornament outline was still sharp and in general the terra cotta was as good as when built. E.P.R.

Terra cotta and brick in railroad structures. C. W. Y. CURRIE. *Clay-Worker*, **93** [7], 475–76 (1930).—A detailed description of the use of architectural terra cotta in the construction of buildings belonging to the New York Central Lines, with emphasis on the treatment of the New York Central Bldg., in which an aggregate of 2000 T. of terra cotta were used, and the Commodore Hotel and Hotel Biltmore, in each of which 700 T. were used, is given. Illustrated. E.J.V.

Prominent makers of garden pottery. ANON. *Crockery and Glass Jour.*, **108** [4], 41–42 (1930).—In this article are listed a number of manufacturers of garden-ware pottery together with some of their outstanding creations. E.P.R.

BOOKS

Problems in Architectural Drawing. Book II. Masonry and Steel Construction. FRANKLIN G. ELWOOD. The Manual Arts Press. *Arch. & Bldg.*, **62** [5], 158 (1930).—This book should prove of value to draftsmen studying in an architectural office who have had beginning training. It is essentially a problem book showing the methods of presenting structural details. E.P.R.

Architectural Drawing. G. D. G. HAKE AND E. H. BUTTON. B. T. Batsford, Ltd., London, 1929. *Mech. World*, **87** [2266], 539 (1930).—A handy book containing the essential parts of this branch of an architect's training. E.P.R.

White Wares

Commercial feldspars produced in the U.S. F. P. KNIGHT, JR. *Jour. Amer. Ceram. Soc.*, **13** [8], 532–49 (1930); for abstract see *Ceram. Abs.*, **9** [3], 210 (1930).

Feldspars and their peculiarities as ceramic solvents. ARTHUR S. WATTS. *Jour. Amer. Ceram. Soc.*, **13** [8], 550–54 (1930); for abstract see *Ceram. Abs.*, **9** [3], 210 (1930).

Continental Faience and Tile Co. ANON. *Ceram. Ind.*, **15** [1], 69–73 (1930).—Carl Bergmans has developed an up-to-date plant, firing most of the tile produced in a 140-ft., oil-fired tunnel kiln. An illustrated description of the plant, processes, and products is given. W.W.M.

Manufacture of porcelain and steatite insulators. ANON. *Engineering*, **129** [3357], 632–35 (1930).—The insulating materials are either ceramic or nonceramic.

The latter include paper, oil, rubber, and their derivatives. The former may be classed into (1) large insulators and (2) fittings. The first of these divisions has shown the greatest development in recent years. The method of manufacture of high-tension porcelain is described. The insulators at the end of the manufacturing processes are examined for mechanical and glazing faults and tested for 15 minutes at their flash-over voltage. The steel and malleable fittings are subjected to a load of 50% above normal before assembly. After assembly each insulator is tested mechanically to 25% above its working load. In addition a proportion of each batch is sent to a research laboratory which includes a high-tension room, mechanical laboratory, fog room, and an open-air testing field where mechanical and electric properties of insulators are exhaustively examined. The fog room has arrangements for producing heavy fog, mist, salt spray, and artificial fouling by solid matter. A 30-ton tensile and compression machine and a 10-ton auxiliary machine equipped with parts to make torsion and bending tests and a machine to carry out the vibration test are all illustrated. In one type of insulator, the pin is secured in the porcelain by cement, in the second, a spiral spring of high-tension steel wire is placed on the head of the pin and is forced through the neck of the hollow cylindrical space in the head of the insulators. The spring is retained in position by a serrated collar and clip and after its insertion the neck is filled with a lead alloy. The tension on the pin is converted into a uniform compression over the whole of the interior of the insulator and the mechanical strength of the combination is higher than that attainable with cement. The manufacture of steatite insulators is analogous to that of porcelain insulators; dry pressing, however, is employed. Steatite insulators have a much higher tensile and bending strength than porcelain and are used in the manufacture of solid core, stick insulator, and other pressed articles of high accuracy and strength. On firing to 1450°C steatite contracts 2% while porcelain contracts 18%. New factory of Messrs. Steatite and Porcelain Products, Ltd., at Stourport, Worcestershire, London, is described. A.A.

Material used for both insulator and conductor. ANON. *Sci. Supp.*, **71** [1833], 12 (1930).—Thyrite, a molded compound including silicon carbide, will prevent the flow of electricity at low voltages and allow it to pass at high potentials. K. B. McEachron, General Electric engineer, reports that it is an ideal material for protecting power lines from the great damage caused by lightning. The new material resembles black slate in color, and has the mechanical properties similar to those of dry-process porcelain. G.R.S.

Large insulator manufacture. ANON. *Elec. Rev.*, **106** [2739], 976–77 (1930).—Established in 1907 for the manufacture of magnesia rings and nozzles for the incandescent gas-mantle trade, Steatite and Porcelain Products, Ltd., later undertook production in increasing quantities of electrical insulators, particularly those refractory to changes of temperature. The history of this plant is given together with its system of manufacture and electrically testing porcelain insulators. E.P.R.

PATENTS

Insulator. WALTER H. SCHRAMM. U. S. 1,764,418, June 17, 1930. An insulator comprising a tubular insulating member, a strain insulator disposed therein with an end inwardly offset from an end of the tubular member and an end-closure member of discoidal sheet-material character having its outer perimeter coöperating with the end of the tubular member and a depressed central portion coöperating with the end of the strain insulator.

Insulator. WALTER H. SCHRAMM. U. S. 1,764,419, June 17, 1930. An insulator comprising a central insulating column of substantially frusto-conical shape, a base member having a central projecting portion embedded in the larger end of the column

and a laterally extending flange, a terminal member having a central projecting portion embedded in the smaller end of the column and a laterally projecting flange, and a tubular insulating member surrounding the column between the flanges.

Insulator structure. LAURENCE R. WILDER. U. S. 1,766,576, June 24, 1930. Insulating means comprising a hollow insulating member open at both ends, and a fastening member therefor having a face fitting against the adjacent end face of the insulating member and an element extending into and being disposed in spaced relation with respect to the adjacent end of the latter to provide a space between the members for receiving cementitious material poured into the space in the plastic state by way of the other end of the insulating member, the adjacent fitting faces of the members being complementary to each other and formed respectively to provide a seal of the male-and-female type operating to confine the material against leakage while in such state between the faces.

Insulator for electric conductors. FRANCIS HERBERT BRAMWELL. U. S. 1,766,593, June 24, 1930. The combination of a vessel of electrically conductive material adapted to withstand high internal pressures and having a wall provided with an opening therein, an electrical conductor passing through the opening from the exterior to the interior of the vessel without making electrical contact with the vessel, and being provided with a shoulder disposed inside the vessel, the shoulder being larger than the mouth of the opening through the wall of the vessel and having an annular seat facing the edge portions of the mouth of the opening and inclined outwardly from its inner circumference and away from the mouth of the opening, a corresponding annular seat being associated with the inside of the wall of the vessel around its opening and presenting a surface inclined outwardly from its inner circumference and oppositely divergent with respect to the inclined face of the shoulder, an annular washer of insulating material presenting opposed surfaces to the seats, the opposed surface being tapered from the outer rim of the washer toward its center, the washer thus having a trapezoidal cross section wherein the larger base is the outer periphery of the washer and fitting snugly between the seats associated with the shoulder of the conductor and with the wall of the vessel, mechanical means for compressing the washer between the seats, the vessel and the conductor being out of electrical connection through the mechanical means and gas under high pressure within the vessel, the pressure of the gas acting upon the outer periphery of the washer and tending to wedge the washer between the tapered surfaces presented by the seats.

Insulator guard. JOHANNES HOLZEL. U. S. 1,766,636, June 24, 1930. The combination with a line insulator having connection members at its ends, of a hoop mounted on the insulator between the connection members and radially extending portions carried by the hoop, the radial portions extending from the hoop for such distance as to prevent short circuiting of the connection members.

Mold for tile. GARFIELD W. FISHER AND CARL G. HENRIKSON. U. S. 1,768,045, June 24, 1930. A mold or die for tile, comprising means for pressing the tile into shape and for simultaneously shaping the edge of the tile, the means comprising an inner box and an outer box, upper and lower die members, a mitered frame around the upper die member movable within the outer box, and springs holding the inner box against the frame.

Insulating bushing. GEORGE A. BURNHAM. U. S. 1,769,175, July 1, 1930. An oil-containing insulating bushing consisting of a lower insulating shell containing oil and which is open at the top and has an opening through its bottom, a conductor extended axially in the shell through the open top and into the bottom opening and having an oil-tight seal at the bottom opening, a metal attaching member encircling and secured to the shell intermediate, its ends, and substantially below the open top, the shell adapted to

contain oil to a level substantially above the top of the attaching member, in which oil the conductor is immersed, an oil-free upper insulating shell which is open at the bottom and has an opening in its top in which the conductor is received disposed over the open top of the lower oil-containing shell and surrounding and depending over the side wall of the shell and having its open bottom terminated substantially below the open top of the lower shell, and means detachably joining the bottom of the upper shell and the attaching member, the means constituting a support for the outer shell.

Oil-filled bushing. GUSTAV E. JANSSON. U. S. 1,769,261, July 1, 1930. (1) In an insulator, the combination of a connecting member, an insulating member, an interposed compressed packing member against which the insulating member bears forcibly, and a cemented connection between the insulating and connecting members holding them in the aforesaid relation. (2) An oil-filled bushing comprising a conductor, an insulating tube surrounding the conductor, and a sectional insulating shell having means permanently uniting its sections enclosing the conductor and tube and having an opening at the top through which the conductor and tube are removable.

Oil-filled bushing. GUSTAV E. JANSSON. U. S. 1,769,262, July 1, 1930. An oil-filled insulator having two adjacent insulating members, a collar disposed around the proximate ends of the members and spaced therefrom, a compressible packing disposed between the proximate ends of the insulating members and held in compression by the members, and a body of cement contained in the space between the members and collar and holding the insulating members and the packing in compressed condition.

Automatic profile, trimmer, and jigger combined. WILLIAM J. MILLER. U. S. 1,769,527, July 1, 1930. The combination with a jigger provided with a reciprocating member moving in unison therewith, of a resiliently mounted profile, and means cooperating with the reciprocating member for moving the profile into operative position.

Feeding and forming plastic material in the manufacture of pottery. WILLIAM J. MILLER. U. S. 1,769,528, July 1, 1930. Means for automatically extruding plastic material forcefully against the forming surface of a mold, and means for rotating the mold.

Feeding and forming plastic material in the manufacture of pottery. WILLIAM J. MILLER. U. S. 1,769,529, July 1, 1930. A container for plastic material, and means removably associated with the lower extremity of the container for confining a charge of plastic material and conforming it to the contour of a mold.

Feeding and forming plastic material in the manufacture of pottery. WILLIAM J. MILLER. U. S. 1,769,530, July 1, 1930. Means for progressing a mass of plastic material into a profile member adapted to temporarily retain a portion of the mass, and a reciprocating member for extruding the material in charges through the walls of the profile member.

Mold for forming artificial teeth and facings. LAKE H. SPRINKLE. U. S. 1,769,807, July 1, 1930. (1) In a mold for forming artificial teeth and facings a pair of substantially horizontally disposed holders for part-molds, multiple pairs of part-molds, stems on the part-molds positioned between the holders, and openings in the holders to fit the stems, for detachably connecting the part-molds to the holders. (2) In a mold for forming artificial teeth and facings one or more pairs of individual male and female part-molds, a seat on one part-mold of each pair, a berm on the other part-mold, to fit the seat, and a curtain wall on the periphery of the female part-mold, to overlap and encompass the upper end of the male part-mold below the seat and the berm, the curtain wall extending all around the upper end, thereby encompassing the same when the part-molds are brought together with molding material therein, whereby the material may be compressed between the part-molds before the berm comes into contact with the seat.

Insulator. RUSSELL P. DUNMIRE. U. S. 1,770,130, July 8, 1930. In an insulator

the combination with a tubular member of a plurality of insulator rods disposed therein, a plurality of insulator units yieldingly mounted in longitudinally superposed relation on the tubular member and terminals engaging the tubular member and insulating units, the rods being joined to the terminals at their respective ends.

Insulator rack. NORRIS C. HUSTED. U. S. 1,770,138, July 8, 1930. In a secondary rack, two angle sections arranged in reverse, parallel, and spaced relation to form a base having a flat back and a longitudinal channel flanked on opposite sides by the adjacent forwardly projecting legs of the sections, support arms extending outwardly from the base and arranged so that their inner ends straddle the forwardly projecting legs and means formed on the arms so as to constitute spacers between the forwardly projecting legs.

Firing rack. BARTHOLOMEW H. GREENE. U. S. 1,770,206, July 8, 1930. In combination, a sagger, a layer of sand upon the bottom of the sagger, and a firing rack for the sagger upon the sand, means extending upward from and integral with the rack spacing the edge of a plate supported thereon entirely above the bottom of the sagger and out of contact with the sand, and means extending downward from the rack imbedded in the sand preventing lateral displacement of the rack in the sand.

Equipment and Apparatus

Grinding-sieving machines. ANON. *Le Ciment* (July, 1929); *Pit and Quarry*, **18** [13], 112 (1929).—Grinding-sieving machines designed to transform diverse materials to a powder are constructed so that after the grinding elements reduce the material to a powder, the latter is pressed against a sieve which permits mechanical sorting at the same time. Friction upon the perforated plate is obtained by means of moving brushes. E.P.R.

Progress in sifting technique. ANON. *Tonind.-Ztg.*, **54** [37], 631 (1930).—A new grinding separator "Ventoplex," which increases the efficiency of output from 30 to 50%, is described. M.V.K.

Shortened high efficiency tubular mill. HERMANN ECKARDT AND WALTER DIEMKE. *Tonind.-Ztg.*, **54** [36], 605–609 (1930).—The authors discuss the special features of a shortened high efficiency tubular mill and compare its work to the work of other mills. M.V.K.

Machine crushes and pulverizes rock. ANON. *Pit and Quarry*, **19** [2], 120 (1929).—A machine known as a rock breaker and pulverizer is designed especially for the reduction of non-metallic rocks such as granite, quartz, dolomite, limestone, cement rock, shale, fluorspar, feldspar, and phosphate. It will do the work of a crusher and secondary rolls in one operation. All parts are of steel and guaranteed against breakage in normal service. The shoes on the revolving member are easily replaced. The machine has a feed opening 8 in. x 16 in., weighs 3000 lbs., and requires 9 to 15 hp. It will reduce 200 to 300 T. of tough, hard rock per day from feed size to $^1/_4$-in. or even 20-mesh. E.P.R.

Apparatus for determining fineness of grinding of cement. G. BAIRE. *Rev. mat. constr. trav. pub.*, No. 248, pp. 182–84 (1930); for abstract see *Ceram. Abs.*, **9** [8], 660 (1930). A.J.M.

Torkret concrete pump. ANON. *Z. Ver. deut. Ing.*, **74** [20], 642–43 (1930).—Description of a pump to transport concrete from the mixer. It will handle a thick plastic concrete readily. One man is required for its operation. At the Leipzig Exposition it handled concrete at a distance of 165 m. and to a height of 40 m. Illustrated. L.T.B.

New type hydraulic press. ANON. *Ceram. Ind.*, **14** [6], 685 (1930).—Oil is used

as a pressure medium. It is semi- or fully automatic with a variable stroke. It requires small floor space and no outside source of pressure. W.W.M.

Shaking machine for analytical work. A. L. ROMANOFF. *Science*, **71** [1838], 320 (1930).—A diagram with explanation of a shaking machine is given. Many samples can be shaken at one time. The container has three rows of compartments providing mild, moderate, and intense shaking. G.R.S.

Positive infinitely variable gear for glass manufacture. ANON. *Glass*, **7** [3], 98–99 (1930).—The principle employed by this chain gear is that of two pairs of expanding pulleys of the opposite conical type, mounted on longitudinal ribbed shafts, one pair on the constant speed shaft, the other on the variable speed shaft. Power is transmitted from one shaft to the other by a patent chain belt which rides in the V formed between each pair of opposing disks. The mechanism controlling the movement of the disks is so arranged that as one pair closes together the other pair separates, so causing the chain to rise in one wheel by the amount it descends in the other, the alteration in the two driving diameters producing variation in speed. This arrangement allows the speed of the driven machine to be changed while under load and without stops. The gear is operated by means of an internal control screw. A hand wheel outside the gear case rotates the control screw. The gear is protected against rust, fumes, grit, etc. All bearings and thrusts are of the ball type. It is used on the drive of conveyers carrying bottles from the bottle machine to the leer, synchronizing the conveyer belt with that of the leer, on machines where the tube is converted into small bottles and containers, to sheet glass machines where one roller must run a definite fraction faster than the other. The new gear enables the desired speed to be obtained rapidly and to be maintained constant. H.W.A.

Tangent meter for graphical differentiation. O. W. RICHARDS AND P. M. ROOPE. *Science*, **71** [1837], 290–91 (1930).—The description is given of a simple device for the direct measurement of the tangent to a curve at any point. Numerous applications will appear to those who do graphical work involving rates of change, especially in case the equation of the curve to be differentiated is unknown. The instrument may also serve as an aid in curve fitting. A detailed description and scale drawing of the instrument are given as well as the method of using it. G.R.S.

New regulator allowing rapid changes in temperature setting of the thermostat. M. J. POLISSAR. *Jour. Amer. Chem. Soc.*, **52** [2], 636–37 (1930).—P. describes a vapor-pressure regulator that can be used at widely different temperatures. R.G.M.

"Universal" oil burner. ANON. *Glass*, **7** [4], 140–41 (1930).—This oil burner is designed so that its application to modern glass processes is now possible. It is possible to obtain the soft rolling flame associated with gas firing and at the same time, by proper control of the ignition point, to use the burners satisfactorily in cases where the combustion space is very limited. H.W.A.

New small water-storage heater. A. RITTERSHAUSSEN. *Electrotech. Z.*, **51** [1], 12–13 (1930).—R. describes a small and simple water-storage heater and points out that a tariff based on the maximum peak load of the consumer would result in the use of the water heater only by night. M.A.B.

Use of ultra-violet light in microscopic measurement of particle size. G. HASLAM AND C. H. HALL. *Jour. Frank. Inst.*, **209** [6], 777–89 (1930).—A description is given of new developments in mounting a pigment for photomicrography, and the use of ultra-violet light for increasing the resolution obtainable when dealing with fine particles. The article includes data obtained by this method of measuring extremely fine particles. M.A.B.

Balancing of small rotating parts. W. SPÄTH. *Electrotech. Z.*, **51** [1], 86–89 (1930).—S. describes an electrical balancing table for small high-speed rotating parts

down to a weight of 1/4 lb. The principle is the use of electromagnets to balance out the mechanical vibration due to unbalance. Illustrated. M.A.B.

New remote indicating and metering methods. W. STERN. *Electrotech. Z.*, **51** [1], 77–80 (1930).—The advantages of remote indication can be combined with remote control in extensive systems. A description is given of an impulse relay. M.A.B.

Testing the resistance to breakage of uneven plates. E. ALBRECHT. *Tonind.-Ztg.*, **54** [40], 671–73; [44], 734–35 (1930).—A new apparatus for testing the resistance to breakage of plates is described, in which the test piece is laid on a number of steel balls arranged in a circle. This method is especially adapted for testing stoneware, glass, slate, and other kinds of plates, particularly uneven plates of the same materials. The following advantages are obtained: (1) the samples do not need to be specially prepared for the tests; (2) the reliability of the results, therefore, does not depend on the carefulness of the preparation of the sample; (3) this method is quick, as the apparatus, once centered, does not need to be centered for every test piece; (4) the variation of results is smaller than with other methods; (5) when the pointed weight is in the middle, the resistance to bending does not depend on the radius of the supported circular area, or on the supporting width. M.V.K.

Pneumatic loading and unloading of lime cars. F. KIRCHBERG. *Tonind.-Ztg.*, **54** [42], 704–706 (1930).—The great efficiency and rapidity of the pneumatic installation described by K. for loading and unloading lime cars testify to its economic value. M.V.K.

Precautions for de-aeration and dusting of ceramic plants. H. REININGER. *Sprechsaal*, **63** [26], 479–83 (1930).—Examples and illustrations of different kinds of de-aeration systems for removing suffocating gases, vapor, and dust in ceramic plants are described. When necessary, the mechanical methods can be supplemented by chemical agents or physical processes (precipitation and absorption) according to the quantity and nature of the gases present. M.V.K.

Pickling solution containers. ANON. *Glashütte*, **60** [12], 193–95; [13], 210–12 (1930).—This article summarizes the various types of materials which are in use as containers for pickling solutions in the enamel industry with recommendations for their improvement. L.T.B.

An electric eye for determining temperature. ANON. *Mining and Met.*, **11** [283], 371 (1930); *Blast Fur. Steel Plant*, **18** [5], 823–24 (1930); *Can. Chem. Met.*, **14** [6], 40 (1930).—By means of the photoelectric cell, popularly known as the "electric eye," industry is assured of an accurate automatic process to be substituted for human eyesight and judgment in determining temperatures in various processes of manufacture. A photoelectric cell unit was placed on the table beside a glow heater and a meter calibrated in degrees temperature. When a varying current was made to pass through the heater, which caused the temperature of the heating element to rise or fall, the slightest change caused an instantaneous variation in the reading of the meter. In all processes where accurate control of temperature is essential, and where human eyesight is fallible, the electric eye readily indicates temperatures from 1300°F up to the highest degree of heat encountered. E.J.V.

Invents "electrical eye" for detecting flaws in bottles. A. L. DUVAL D'ADRIAN. *Ceram. Ind.*, **15** [1], 45 (1930).—D. has invented an electrical apparatus for detecting and measuring the amount of strain in glass bottles. Formerly this measurement was made by eye with the aid of a polariscope. A beam of light passes through a prism like that of the polariscope, through the bottle, and then through another prism like the first, to a photoelectric cell. The light-energy reaching the cell varies with the strain in the glass bottle. The energy from the cell is amplified and read on a voltmeter. A disk with equally-spaced holes rotates in the beam of light between the bottle and the second prism, causing the cell to emit a pulsating current which is easily amplified. W.W.M.

New pycnometer measures free moisture in aggregates. D. D. McGuire and W. H. Rowan. *Concrete*, **36** [5], 41 (1930).—This apparatus is used as a means of control of concrete mixtures by the Tennessee Highway Department. The advantage of this equipment is that a sample as large as 20 lbs. may be used and errors attendant with small samples eliminated. The accuracy of the test is within 0.1%. The apparatus is described and the formula for per cent moisture is given. H.W.A.

Application of trilinear charts to aggregate grading control. T. E. Sheafer. *Concrete*, **36** [4], 33–35 (1930).—The use of trilinear charts has simplified the aggregate grading control in stucco plants and is much easier than the trial batch methods. The method of reading charts and plotting sieve analyses is given in detail. The application of the trilinear charts to aggregate grading control is illustrated. The viewpoint of economy is an important factor in the use of the charts. H.W.A.

Slide rule simplifies orifice-flow calculations. H. G. Hyland. *Power*, **71** [25], 997–99 (1930).—A flow-meter slide rule has been designed to take care of practically all variables entering into the calculations. The general orifice-flow equations are given and explained. The equations for the design of the slide rule for gas-flow, steam-flow, and liquid-flow calculations are given and explained. The operating instructions for the slide rule are listed in order. H.W.A.

Mold finishing by power-driven tools. Robert Scheidweiler. *Diamant*, **51** [22], 428–29 (1929).—A portable motor driving through the media of cone pulleys, countershafts, and flexible shaft, a grinding wheel, a milling cutter, a scratch brush, buff, or file, as might be the case, for finishing the surface of glass molds is described. The outfit is particularly suitable for work on molds for pressed ware. By using the edge of the large pulley of the countershaft to drive a small pulley in the flexible shaft by friction instead of taking the drive direct from the countershaft spindle, high speeds are obtainable. Illustrated. See also *Ceram. Abs.*, **8** [12], 874 (1929). E.J.V.

Electrical power in brickworks. II. Anon. *Brit. Clayworker*, **38** [452], 323–24 (1930).—A discussion on the wiring of motors and the control apparatus necessary to protect them when starting and operating as applied to direct and alternating machines. **III.** *Ibid.*, **38** [455], 443–44 (1930).—A discussion on the advantages of purchasing electrical power from a producer as against private generation of same. **IV.** *Ibid.*, **39** [456], 8–10 (1930).—A discussion on the use of electrical power in brickworks with special reference to systems of charging and factors governing generating costs. For Part I see *Ceram. Abs.*, **8** [11], 809 (1929). R.A.H.

Electrical power in brickworks. VI. The measurement of power. Anon. *Brit. Clayworker*, **39** [458], 86–87 (1930).—A discussion of the various instruments used for measuring the consumption of power in various departments of the plant and the advantage gained by keeping a check on the power so consumed. For Part V see *Ceram. Abs.*, **9** [8], 661 (1930). R.A.H.

Apparatus for cutting brick, etc. P. Renault. *Rev. mat. constr. trav. pub.*, No. 248, pp. 92–93B (1930). A.J.M.

Machine-made brick and artificial drying. P. Thor. *Tonind.-Ztg.*, **54** [42], 703–704 (1930).—Artificial drying of brick is most difficult because of the great water content and shrinkage of brick and their horizontal position during drying, which cannot be changed and which retards drying. T. describes a new drying installation, consisting of 22 chambers with a production of 90,000 to 95,000 brick per week, working according to the two-chamber system with a vertical motion of the drying air. The advantage is that the time required for drying is about 4 to 5 days instead of 7. M.V.K.

Pneumatic diggers get out clay for brickmaking. Anon. *Clay Prod. News*, **3** [6], 4–5 (1930).—The art of making brick in England dates back to the days when Britain was held by the Romans. Following the withdrawal of the Romans fired brick

ceased to be made until about the 13th Century. The devastating fire that swept London in 1666, wiping out thousands of structures fashioned largely of timber, emphasized the advantage of brickwork. Since 1893, Cocking & Sons, Ltd., Yorkshire, has helped to supply this need from what is known as boulder clay which is extremely tenacious. Recently, air-driven clay diggers have been utilized instead of picks, bars, and explosives. Four men and four diggers do what used to require the labors of six men and 40 lbs. of explosives. The equipment has reduced the previous cost of getting out the clay 33%. The air needed to operate the four pneumatic diggers in the pit is furnished by a 7- by 7-inch ER-1 Ingersoll-Rand compressor. The compressor is of recent type, and is suitable where the load varies more or less continuously during the working hours. W.C.O.W.

Maco template. ANON. *Blast Fur. Steel Plant*, **18** [6], 1026 (1930).—A description of this unique instrument for measuring contours is given. Illustrated. For abstract see *Ceram. Abs.*, **9** [8], 658 (1930). E.J.V.

New Foxboro differential limit recorder-controller. ANON. *Gas Age-Rec.*, **65** [24], 911 (1930).—The satisfactory measurement of widely varying flow has always been a troublesome problem. The Foxboro Co. has perfected a new instrument known as a differential limit recorder-controller. Once installed, the differential limit controller continually gives a record of the gas flow through the line. This controller is known as the primary meter. It is specified to handle the minimum rate of flow with commercial accuracy. When the differential range is exceeded, the control functions and automatically opens a valve which puts the secondary meter in operation. This secondary meter is a complete Foxboro gas flow meter operating in the by-pass. When the secondary meter goes into operation, it doubles the effective capacity of the set-up. As soon as the secondary meter line is open the differential pressure drops, because of the increased capacity. The valve in the secondary meter line is held open by the controller until the flow is again within the capacity of the primary meter. The valve is then closed automatically and the primary meter again assumes the entire load. The operation is entirely automatic from start to finish. Illustrated. E.J.V.

Well type manometer checks up combustion mixtures. ANON. *Gas Age-Rec.*, **65** [24], 912 (1930); *Blast Fur. Steel Plant*, **18** [7], 1172 (1930).—A novel type of flow meter has recently been manufactured by the Meriam Co., Cleveland, Ohio, for measuring the mixture of liquid or gaseous fuel used in furnaces. The new instrument is made up of a series of compact manometer units. This makes it particularly adaptable to large groups of furnaces and, being simple and rugged, it is not liable to failure or inaccuracy. In a single manometer unit for measuring the flow of both gas and air to one furnace or group, the two U-tubes are connected to a single reservoir or "well," which is large in volume compared with the U-tubes, although small in actual cubical content. The well is partly filled with suitable liquid and the free ends of the U-tubes are connected to pipes tapped off the supply lines of air and of gas, respectively. Illustrated. E.J.V.

New thermostat to control industrial heating units. ANON. *Blast Fur. Steel Plant*, **18** [6], 1026 (1930).—The General Electric Co. announces the CR-2992-A-1 thermostat for use with industrial heating units where very close control of the heat is not required. The new device is available in three principal ratings and the operating ranges are (1)60 to 200°F, (2) 150 to 300°F, and (3) 250 to 400°F. The current-carrying capacity is 15 amperes at 115 or 230 volt a.c., or $^1/_4$ ampere at the same voltages d.c. The thermostat will operate with a differential of 5% of the maximum temperature range. Illustrated. E.J.V.

Air cleaner for grinder motors. ANON. *Brass World*, **25** [5], 132 (1930).—Cleaning the air which is drawn through the motors of grinders to keep them cool and hence

more efficient is a development of the Hammond Machinery Builders, Inc. Motor air cleaners are installed on all machines of three or more horsepower. All the incoming air passes through the centrifugal cleaner. Illustrated. E.P.R.

New regulating valves. HAUCK MANUFACTURING CO. *Brick Clay Rec.*, **76** [12], 782 (1930).—The Hauck Micro-Vernier Oil Regulating Valves are claimed to give instant and positive regulation of any type oil burner and can be used with any grade of fuel oil at all operating pressures. The new regulating valve is said to save fuel, avoid clogging troubles, save time, and eliminate the "fading away" flame so often experienced with needle and other types of valves. Increase or decrease in the oil flow is secured to a very fine degree because one-tenth of a turn of the hand-operated regulating wheel moves a sliding shoe 0.005 inch across a very accurately machined, knife-edged opening. Illustrated. E.J.V.

Automatic Switch Co. develops addition to "Asco valves." ANON. *Gas Age-Rec.*, **65** [19], 700 (1930).—A new solenoid magnet-operated gas-control valve listed as type "P.N.A.," equipped with a by-pass for pressures up to 10 lb., is the latest addition of the Automatic Switch Co. to its "Asco Valve" series. The "N" group to which it belongs are double-seated, partially balanced, and are especially adapted for control of cooling water on condensers, compressors, etc. They are of two types, *i.e.*, normally closed and normally open. They have a wide field of application for high and low pressure gas used under by-pass conditions. Illustrated. E.J.V.

Feldspar and flint plant in New Jersey employs pumping of dry solids. H. P. MARGERUM. *Pit and Quarry*, **20** [4], 50–52 (1930); for abstract see *Ceram. Abs.*, **9** [7], 552 (1930). E.P.R.

Vibrating screens in French cement industry. PAUL BERTIER. *Le Ciment*, **35** [4], 146–47 (1930); *Pit and Quarry*, **20** [6], 77 (1930).—B. recommends a more general consideration of the electric vibrating screen by the cement industry to improve the product by installing a vibrator in closed-circuit with the primary grinding mill and allowing a more efficient operation in the secondary stage. In certain installations it has been possible without any modification of the existing grinding mills to obtain an increase of 25% in the capacity of the secondary mill. E.P.R.

BOOKS, PAMPHLETS, AND CIRCULARS

Materials Handling Equipment. EDWARD J. TOURNIER. McGraw-Hill Book Co., N. Y., 371 pp. Price $4.00. Reviewed in *Mining and Met.*, **11** [282], 22 (1930); for abstract see *Ceram. Abs.*, **9** [4], 298 (1930). E.J.V.

Bearing Metals and Bearings. W. M. CORSE. Chemical Catalog Co., Westman Publications, Ltd., Toronto. 374 pp. Price $7.00. Reviewed in *Can. Chem. Met.*, **14** [6], 56 (1930).—A history of the development of bearings and bearing metals is presented, which includes the summing-up of the present situation and ends with a discussion of lubricants. The second section is a well-classified bibliography of papers related to the subject. A third section consists of abstracts from the principal papers which have been produced on this subject. A series of tables, giving specifications and properties for bearings including the composition of materials used under different conditions, is included. E.J.V.

Electroplating with Chromium, Copper, and Nickel. BENJAMIN FREEMAN AND FREDERICK G. HOPPE. Prentice-Hall, N. Y. 212 pp., illus., diagrs. $5.00. Reviewed in *Mining and Met.*, **11** [282], 22 (1930).—A practical guide for the electroplater, covering the electrochemical principles involved, preparation of the work, preparation of baths, equipment, and methods of plating, is presented. Special attention is given to chromium plating. E.J.V.

Dry dust collectors. ANON. *Pit and Quarry*, **19** [2], 105 (1929).—By-Products

Recoveries, Inc., has published a 4-page pamphlet which explains the principle and design of dust-collecting equipment particularly adapted to cement and gypsum mills. E.P.R.

Best nonclog rock breakers, granulators, and pulverizers for mines, roads, quarries, and milling companies. ANON. *Pit and Quarry*, 19 [2], 105 (1929).—Circular No. 7, Best Machinery Co. illustrates and describes various sizes and types of rock-crushing equipment. E.P.R.

PATENTS

Making clay pots. FRANK W. PRESTON. U. S. 1,765,804, June 24, 1930. Apparatus for forming articles of plastic material comprising a mold, a roller, means for imparting relative movement to the roller and mold to compress the material against the mold, and means for simultaneously kneading the material.

Tile-molding machine. JOSEPH PESSAGNO. U. S. 1,765,847, June 24, 1930. A tile-molding machine having two coacting mold sections, means for reciprocating one of the sections and mutilated gears having coacting lugs for revolving the other section intermittently and in timed relation to the reciprocation of the first-named section.

Measurements of the calorific value of combustible gases. HORACE N. PACKARD. U. S. 1,767,771, June 24, 1930. The method of calorimetry which comprises effecting a chemical reaction involving a given agent definitely proportioned relatively to another substance and effecting predetermined variations in the relative proportions of such agent and other substance automatically in response to variations in certain calorific effects of the reaction.

Woven-wire screen. MORLEY PUNSHON REYNOLDS. U. S. 1,767,814, June 24, 1930. A woven-wire screen comprising a series of spaced parallel wires, and a second series of transverse wires, the wires of the second series being arranged in spaced groups, and the two outermost wires in each such group being secured to certain of the wires of the first-named series.

Tool for applying coating. WAYNE B. THOMPSON. U. S. 1,767,822, June 24, 1930. In a spray gun, the combination with a source of supply for the coating material, including an outlet for the coating material and an inlet for atmospheric air, and means for producing a condition of unbalanced pressure within the source of supply whereby the atmospheric air forces the coating material through the outlet of a valve for closing the inlet during the operation of the spray gun.

Polarimetric apparatus. MAX BEREK. U. S. 1,767,831, June 24, 1930. In polarimetric apparatus, a lens, a rotatable body containing a substance to be analyzed, an analyzer between the lens and body, a polarizer, a half-shade wedge in front of the same, and a tiltable glass plate between the half-shade wedge and the glass plate.

Magnetic separator for spouts. HOWARD H. MOYER. U. S. 1,769,268, July 1, 1930. A device of the character described, comprising a spout having a discharge opening in its bottom side, a magnetic separating element arranged transversely within the spout opposite the opening for intercepting and collecting any metallic particles present in the material flowing therethrough, and a closure for the opening controlled by the separating element for governing the discharge of the metallic particles from the spout.

Testing physical qualities of materials. BRITISH CAST IRON RESEARCH ASSOCIATION, W. J. REES, AND J. G. A. SKERL. Brit. 327,306, May 21, 1930. Apparatus for measuring the permeability of sand and like aggregates to gases comprises a sand container through which gas is passed from a gas chamber and ignited at the other end, the time between the admission to one end of the sand container and ignition at the other end being taken as a measure of the permeability. A container closed at the

bottom by a wire gauze or perforated plate and at the top by a cap with a central perforation is secured to a gas chamber to which gas is admitted by a cock. A manometer is provided for reading the gas pressure. A pilot flame serves for igniting the gas issuing at the top.

Brick presses. T. E. FAWCETT, LTD., AND D. L. FAWCETT. Brit. 328,068, June 12, 1930. In a crank- or eccentric-operated vertical plunger brick or like press means are provided whereby on the attainment of a predetermined downward pressure on the brick an upward pressure is applied to it.

Crucible fusion furnace heated by solid, liquid, or gaseous fuel. JOHN PENICUD. Fr. 676,565, June 12, 1929. (*C.A.*)

Kilns, Furnaces, Fuels, and Combustion

Damp foundations of annular kilns. ANON. *Master Builder*, **810**, 66 (1929); *Tonind.-Ztg.*, **54** [26], 455 (1930).—Humidity in annular kiln floors is most frequently due to the dampness of the foundations and the ground around the kiln. Lime and porous ground absorb water from a large area and are considered as a poor location for annular kilns. To secure a perfectly dry floor, a waterproof foundation of concrete about 5 cm. thick and covered with at least 15 cm. of sand should be made for the kiln. The surface of the concrete must be well drained so that the water from above and below is removed automatically; and the foundation should extend the whole length and width of the kiln. In very damp ground the thickness of the foundation should be from 0.9 to 1.2 m. in thickness. In all cases a specially constructed waterproof foundation is necessary under the chimney and flue. The surface of the ground surrounding the kiln must be drained by ditches and covered drain pipes. In some brick and tile plants the draining is so difficult that a pit is dug and pumped dry regularly. In building the foundation, porous refractory clay or brick cannot be used. Portland cement as a mortar is not advantageous as it is soon destroyed by heat. On the other hand salt-glazed plates were found to be advantageous and not too expensive. If the draining is properly taken care of, the only source of humidity in the kiln is the charge. If the brick are damp, the moisture from them is drawn off without condensing on the surface. This is aided by a better kiln draft and by opening one or more dampers so that more gases are drawn off. The consumption of fuel is so great that it is too expensive. Experiments with two principal flues, one for steam and one for the gases were not successful. In ordinary annular kilns each chamber must be closed by a slide after it is charged with brick and carefully dried by the hot air from the cooling chambers or by fire. If the foundation is dry everything must be done to keep it in good condition. Carelessness causes many injuries. M.V.K.

Stopping an annular kiln. J. WELTER. *Tonind.-Ztg.*, **54** [43], 730 (1930); for abstract see *Ceram. Abs.*, **9** [8], 663 (1930). M.V.K.

New kiln for high temperatures with surface combustion. EUGEN RYSCHKEVITSCH. *Chem. Fabr.*, pp. 61–63 (1930); *Tonind.-Ztg.*, **54** [46], 771 (1930).—The technical defects heretofore existing in surface combustion kilns, *i.e.*, the necessity of mixing chambers, difficulties of regulating, etc., are avoided in the new kiln, in that the gases are not mixed in front of the firing space and the resistance to the gas current is reduced. The kiln is constructed of the refractory materials MgO or ZrO_2 and can attain a temperature of over 2000° with illuminating gas, and up to 1900° with generator gas. It is easily regulated. The maximum consumption of gas amounts to about 3.5 up to 4 cu.m./hr. in 200 cu.m. space, about 10 cu.m./hr. in 1 liter, and about 18 cu.m./hr. in 3 liters. M.V.K.

Continuous kiln with two chambers. LUDWIG SCHIELE. *Tonind.-Ztg.*, **54** [37],

626–27 (1930).—S. describes a new continuous kiln with two chambers. While the ware is being fired in one chamber, the second chamber is charged, smoked, and slightly heated, then the hot gases from the first chamber are carefully sent into the second chamber. In this way the kiln works without interruption which has great advantages. M.V.K.

Improving the efficiency of falsely-dimensioned annular kilns. ANON. *Tonind.-Ztg.*, **54** [36], 610 (1930).—Different cases of falsely-dimensioned annular kilns are enumerated. These errors appear especially in the dimensions of flues, valves, and chimneys. The processes of firing in such kilns and directions for improving their efficiency are described. M.V.K.

Repairs on continuous fire kiln when not in operation. J. WELTER. *Rev. mat. constr. trav. pub.*, No. 248, pp. 81–83B (1930); see also *Ceram. Abs.*, **9** [6], 457 (1930). A.J.M.

Insulation in ceramic firing and drying installations. OTTO TH. KORITNIG. *Sprechsaal*, **63** [25], 462–63 (1930).—The smaller the specific gravity is, the lower is the thermal conductivity of insulation. The capability of resisting humidity, frost, heat, mechanical action, and other qualities must also be considered when choosing a material for insulation. L. gives tables with figures of thermal conductivity of different materials and points out in examples the advantages, especially in economy, of using insulation materials. M.V.K.

Tests on firing of porcelain. G. KOPKA. *Repts. Czechoslo. Ceram. Soc.*, **6** [1–2], 17 (1929); *Sprechsaal*, **63** [26], 487 (1930); for abstract see *Ceram. Abs.*, **9** [2], 112 (1930). M.V.K.

Chain conveyer for moving kiln cars. ANON. *Ceram. Ind.*, **14** [6], 684–85 (1930).—A description (illustrated) of a chain conveyer, placed between the tracks on which the kiln cars run, is given. The chain carries a removable dog which engages the frame of the car. W.W.M.

Clinker cooling apparatus in revolving furnaces. H. ILLIES. *Feuerungstechnik*, **18** [11–12], 120–21 (1930).—In the new clinker cooling apparatus of the Mannstaedt type, the clinker falls from the revolving furnace into a funnel cooler, and is quickly cooled by air blown in by a blast apparatus. The air itself is greatly heated during this process and it is sent into the furnace to be used for combustion. A Belgain Portland cement plant used this device with good results, which are given in a comparative table. The advantages of this method are (1) a low consumption of coal in consequence of the utilization of the total heat of the clinker, (2) a uniform fire obtained by the intensive process of combustion in a smaller space and shorter time, (3) easy supervision of the combustion process, and (4) amelioration of the quality of the products in consequence of rapid and uniform cooling of the clinker. M.V.K.

Investigation of the draft, temperature, and combustion conditions in commercial kilns firing building brick. H. P. KIMBELL. Univ. Toronto, School Eng., *Research Bull.*, **8**, 1–34 (1928).—Tests were made on 4 commercial kilns, 2 operating on forced draft and 2 on natural draft sometimes augmented by stack fans. Definite conclusions as to the comparative efficiencies of kilns operating on the 2 types of draft could not be drawn because of the many variable factors encountered during the runs. (*C.A.*)

Built-in and attached producers. F. J. KENNEDY. *Gas Age-Rec.*, **65** [23], 847–48 (1930).—The purpose of this paper on built-in and attached producers is to describe briefly the various types, to consider successes and failures which have been experienced with different grate designs, to discuss operating characteristics, and to attempt a comparison of tests of these types of producers with central producers. Illustrated. E.J.V.

Use of stokers for brick kilns. ANON. *Blast Fur. Steel Plant*, **18** [7], 1183 (1930).—

The possibility of improving the ware and of reducing the costs of firing brick in the downdraft round type of brick kiln is of great interest to all manufacturers using that type of kiln. Some attempts have been made to replace hand-firing by stokers, but without much success. A more intensive study of the application of a stoker to a round kiln is one of the problems of the joint investigation being conducted at Roseville, Ohio, by the U. S. Bureau of Mines, and the O. S. U. Eng. Expt. Station. The primary object at present is to determine how much improvement in ware and saving in fuel can result from a more uniform distribution and closer control of heat. The first installation has one stoker which fires two kilns alternately. The stoker has enabled the operators to control closely the rate of heating, atmosphere in the kiln, and the pressure. This ability to control closely the heat supplied and the gas composition simplifies study of the actions in the kiln during the firing and will procure data which can be applied to hand-fired kilns by indicating control and possible schedules. E.J.V.

Modern tile plant uses continuous gas-fired kilns. J. B. NEALEY. *Gas Age-Rec.*, **65** [20], 724–26 (1930).—The Cambridge Tile & Manufacturing Co., Cincinnati, Ohio, has a new plant for the production of tile of all kinds including bathroom, floor, wall, etc., both in white and in color. Some 30 colors are successfully employed here. Next to correct heat gradients and time cycles, atmosphere is probably the most vital factor in firing colored ceramic products. An oxidizing atmosphere is necessary and its distribution throughout the kiln must be uniform if a uniform product is to be obtained. This is possible only with a mechanical kiln utilizing gas fuel with burner equipment that will exactly proportion the gas-air ratio to provide the required atmosphere. Furthermore, it is possible with this fuel only to obtain exact temperature control. The bisque kiln used is an open-fired tunnel kiln 332 ft. long and 6 ft. wide, fired to approximately 2460°F in the hot zone. There are ten fire boxes, five on each side, and in each of these is located a gas burner of the blast type to which gas is supplied at 6 oz. and air at one pound pressure and there is a two-valve control for regulating the gas-air ratio for perfect combustion. The glost kiln is, in all essential points, a duplication of the bisque kiln, except that the highest temperature is 2100°F. Other features of the plant design and equipment are described. Illustrated. E.J.V.

Overcoming smoking in oil-fired furnaces. F. J. GUTSCH. *Amer. Machinist*, **72** [10], 417–18 (1930); *Trans. Amer. Soc. Steel Treating*, **17** [6], 893 (1930).—A description of an oil-fired furnace developed by the El Paso shops of the Southern Pacific Co. is given, in which rapid heating and smoke elimination are accomplished. Oil is dropped onto a sharp blast of air, which breaks it up into small particles. As the subpreheating chamber heats up, the heat thoroughly vaporizes the oil resulting in almost perfect combustion. E.P.R.

Comparative costs and value of fuels. G. F. KLEIN. *Black Diamond*, **84** [15], 11 (1930); *Trans. Amer. Soc. Steel Treating*, **17** [6], 892 (1930).—The difference in fuel cost is only one of several variables to be considered. Four additional factors are given for oil fuel while three more are given for gas. Total costs of these are compared. E.P.R.

How to get reducing and oxidizing fires. TECK. *Clay-Worker*, **93** [7], 491–92 (1930).—In considering how to get reducing and oxidizing fires, the combustion of coal in a grate furnace is first considered in detail, the combustion process being discussed from the chemical standpoint, the effect of primary and secondary air being taken up. To have an oxidizing fire, the fuel bed should be shallow, the firing should be light and frequent, secondary air must be admitted over the fuel bed and provision made in the furnace construction to thoroughly commingle the gases and air and permit them to burn as completely as possible before coming in contact with the ware. The draft should be free to pull in the necessary primary air and get it through the coal bed

quickly and to pull in the necessary secondary air. To get reducing conditions, have the fuel bed deep, keep the furnace mouths tightly closed to eliminate secondary air, and construct the furnace to enable the gases to get over among the ware as quickly as possible. Weak draft is favorable to reducing conditions. The reactions caused in clays under the two different conditions are described in detail. E.J.V.

Better firing. ANON. *Clay-Worker*, **93** [7], 490 (1930).—There has been a persistent seeking for better firing and perhaps always will be, because it is a vital part of converting clay into finished products. Great strides have been made in the work of firing, reducing to a rather low minimum the percentage of poorly fired ware. Equally important progress has been made in fuel efficiency and in temperature distribution, regulation, and control. Temperature recording and regulating instruments are helping to provide easier and more positive control, and firing methods and devices help reduce the work burden as well as provide for greater fuel efficiency. E.J.V.

Thermal insulation by means of plaster. D. S. *Rev. mat. constr. trav. pub.*, No. 248, pp. 190–91 (1930).—Experiments with a sheet of plaster of Paris showed that after 2 hrs. the side opposite a flame with a temperature of 1040°C attained a maximum temperature of 53°C. A.J.M.

Combustion chamber volume. A. ALISON. *Glass*, **7** [3], 96–97 (1930).—The equation for determining the combustion chamber volume per foot of length, which was inaccurately given in the issue of April, 1929, in "Glass Furnace Construction," is stated correctly and explained. A chart based on the equation is given. For abstract of entire article see *Ceram. Abs.*, **9** [3], 177–78 (1930). H.W.A.

Coal carbonization. ANON. *Glass*, **7** [4], 153–55 (1930).—In the operation of gas producers the quality of the coal is most important. Among the desirable features in a coal is that of a high fusion point of the ash. Considerable attention has been devoted to methods for the determination of the fusibility of coal ash. The deleterious effects of a fusible clinker are recognized. The method usually used consists of molding the ash into the form of "Seger" cones with a suitable binding material. The cones are heated in a furnace and the temperature noted at which the tip of the cone touches the base on which it is mounted or the whole has fused to a spherical lump. In the absence of uniform conditions widely different values may be obtained on the same ash by different investigators. The atmosphere within the furnace is important. A mildly reducing atmosphere has been recommended by some. The method of determination of the fusion point of coal ash described entails determinations in both reducing and oxidizing atmospheres. The following two temperatures are noted: (1) temperature of initial deformation (softening point) and (2) fusion temperature. The difference between (2) and (1) represents the softening interval. The ash is ground to 200-mesh, moistened with 10% aqueous solution of dextrin, and molded into a cone. The cones are air dried and then heated to 800 to 900°C to remove all carbonaceous matter. The furnace has an inner silicon carbide tube and a circulating system so that the products of combustion may circulate over the cones if desired. Condensed water may be removed from the gas. Coal gas may be introduced to give the reducing atmosphere desired. A temperature of 1500°C may be attained under oxidizing conditions. Reducing conditions are obtained by working the furnace with a deficient air supply. A temperature of 1450°C may thus be attained. Methane, carbon monoxide, and hydrogen were taken as reducing gases and oxygen, carbon dioxide, and water vapor as oxidizing gases. The ratios of reducing to oxidizing gases are compared for several tests. The variation in ratios with temperature is comparatively small. Temperatures were measured by (1) Cambridge optical pyrometer (Wanner type), and (2) Foster hot filament type optical pyrometer. The fusion point was determined by placing the cone in the furnace and raising the temperature rapidly to 900°C, focusing

the pyrometer on the tip of the cone and raising the temperature about 5°C per minute until the desired effect is obtained. H.W.A.

Selecting fuel for pulverized-coal installations. C. H. CAMP. *Power*, **72** [2], 55–57 (1930).—Efficiencies below the point justifying investments, excessive furnace upkeep, high grinding, and grinder maintenance costs, smoke and fly-ash troubles are as much the results of improper selection of coal as they are due to improper design. The preferable coal for installations designed for pulverized bituminous coal should be (1) as friable and soft as can be obtained with other specifications, (2) flashy, fast flame propagation, (3) volatile content from 20 to 27%, (4) ash not over 8%, (5) heat value not less than 14,000 B.t.u. per lb., (6) moisture not over 3%, and (7) the coal should be clean. A coal of this character is extremely flexible in pulverized coal burning. Good results are obtainable over a wide range of fineness of grinding and it is adaptable to a wide range of flame air and velocity adjustments. The coal itself will not produce topmost economies as the design of every detail in the plant has its individual effect. H.W.A.

Radiant heat transmission. H. C. HOTTEL. *Mech. Eng.*, **52** [7], 699–704 (1930).—The present status of our knowledge on radiant heat transmission is summarized under three headings: (1) radiation between solids, (2) radiation from clouds of particles, and (3) radiation from clear gases. The first section is presented in great detail. The evaluation of radiant heat interchange between two surfaces involves the Stefan-Boltzmann equation, together with an angle factor which is given for seventeen different surface arrangements, thereby permitting almost any case to be evaluated in terms of one of the standard forms. For those cases in which the angle factor is a complicated function of the variables involved, plots are presented for convenience in making calculations. In Section 2, the theoretical results on the problem of radiation from powdered-coal flames are presented, as well as the objections to them. Analytical and experimental results on the allied problem of luminous-flame radiation are summarized. In Section 3, the status of our knowledge of nonluminous-gas radiation is presented. Problems which remain to be solved are presented in each of the three fields, together with mention of work now in progress in America on such problems. H.W.A.

Transmission of heat through insulation. R. H. HEILMAN. *Mech. Eng.*, **52** [7], 693–98 (1930).—A brief discussion is given of the views formerly held on the mechanism of heat transfer through insulation, together with a short discussion on the present views resulting from the latest researches on heat transfer and heat insulation. The relative importance of the three modes of heat transmission, conduction, radiation, and convection, is discussed, and the conclusion is drawn that there is no transmission by convection through the commercial insulations so far manufactured. For molded types of insulation where the air pockets are infinitesimally small, it is concluded that the transfer takes place entirely by pure conduction. It is also shown that the temperature coefficient for the conductivity of air is sufficiently high to account for the increase in conductivity with temperature of some of the molded types of insulation. For corrugated types of insulation where the air pockets are very large, it is concluded that the transfer of heat by radiation is of considerable magnitude. Formulas are given showing the effect of radiation and conduction on heat transmission as a function of conductivity, pore diameter, and absolute temperature. The effect of metallic paints when applied to the outer surfaces of heat insulation for the purpose of increasing the efficiency are also discussed. Formulas and graphs are included which enable one to readily determine the heat losses by radiation and convection from bare pipes, boiler walls, and other types of surfaces met in industry. H.W.A.

Heat transmission between fluids and solids: conduction and convection. W. H. MCADAMS. *Mech. Eng.*, **52** [7], 690–92 (1930).—The individual coefficients of heat

transfer between solids and fluids are dealt with primarily. There are three classical methods of attack: (1) mathematical, based on the differential equations of hydrodynamics and heat conduction, (2) Reynolds analogy between heat transfer and fluid friction, and (3) dimensional analysis. Each method is discussed and limitations introduced by the various assumptions are indicated. Data are given to illustrate the effect of heat transfer on friction. A graphical method of obtaining individual coefficients of heat transfer from the overall coefficients is outlined, and some precautions advisable in heat-transfer measurements are listed. The work of the National Research Council Committee on Heat Transmission is outlined, and their official symbols for heat transfer are tabulated. H.W.A.

Calculating heating value from chemical composition. H. L. KAUFFMAN. *Power*, **71** [24], 943 (1930).—The advantage of ascertaining heating value from a chemical composition lies in the fact that it gives a check of calorimetric determination and also a method in case calorimetric determination is not available. Dulong's formula gives satisfactory results for the majority of coals. B.t.u./lb. = $[^1/_{100}][14{,}544\ C + 62{,}028\ (H - {}^1/_8\ O) + 4050\ S]$, where C = % carbon, H = % hydrogen, O = % oxygen, S = % sulphur. The term $H - {}^1/_8\ O$ is called the "available" or "disposable" hydrogen. The results are within 1.5% of the actual for most coals not high in moisture. Formulas by W. Steur and R. Vondracek are given which are claimed to give good results with lower-grade coals. H.W.A.

Progress of heat technology during the past ten years. CH. WALCKENAER. *Chaleur ind.* (Special No.), pp. 7–14 (April, 1930). A.J.M.

Modern apparatus for production and utilization of heat. E. ARNOULT. *Chaleur ind.* (Special No.), pp. 259–62 (April, 1930). A.J.M.

Twenty years research on transmission of heat. A. FOCH. *Chaleur ind.* (Special No.), pp. 25–28 (April, 1930). A.J.M.

Recent progress in knowledge of phenomenon of oxidation. A. BOUTARIC. *Chaleur ind.* (Special No.), pp. 20–24 (April, 1930). A.J.M.

Advantages of long firing zone. ANON. *Master Builder*, No. 813, p. 70; *Tonind.-Ztg.*, **54** [17], 291 (1930).—The firing zone of an annular kiln can be divided into three parts, prefire, full-fire, and cooling-fire. If the full-fire zone is not long enough the ware spalls; irregularities of temperature exist causing uneven firing. The rate of increasing the temperature from 600° to full-fire must be carefully determined. Clays with a high content of carbon require long prefiring, while easily melting clays, especially those containing lime, require uniform heating. A long prefire is advantageous in both cases. The number of fire pits in the prefiring zone depends on the kind of clay. For some slate clays 2 rows are sufficient; others require 8, or even 12. Thorough smoking and prefiring permit abrupt temperature increase in the full-fire zone, if the clay is not unusually sensitive. The length of the full-fire zone is conditioned by the length of time necessary for vitrification. The temperature in the full-firing zone should be gradually and uniformly raised for clays sensitive to overheating, but quickly raised for other clays. The best results are obtained with some clays if no more fuel is added. During this pause the heat is uniformly distributed in the chamber, thus lessening the danger from overheating. After each pause, only enough fuel should be added to maintain the finishing firing temperature. If the prefiring has been sufficiently long, no pause in the full-fire is necessary. Very thin and sandy clays cannot be kept too long in the full-fire; the firing zone should be short and the cooling zone long to cool the ware slowly. With the exception of the fuel consumption, most of the defects of a short annular kiln (less than 90 m.) can be regulated by a careful adjustment of the length of the firing zone. In a short kiln with a long firing zone there seems to

be a waste of fuel, but it must be preferred to the short firing zone with a small consumption of fuel because the kiln output is greater. M.V.K.

Saturating dry natural gas with steam or other vapors. H. L. GAIDRY. *Oil and Gas Jour.*, **28** [51], 134 (1930).—New Orleans Public Service, Inc., changed from manufactured to natural gas about 2 yrs. ago. To prevent excessive leakage in the low-pressure system as the result of the joints being dried out by the natural gas, arrangements were made for saturating the gas with steam. The gas is also passed through oil to take up oil vapors. As a result there is no more unaccounted-for gas than before natural gas was introduced. (*C.A.*)

Making gas available to all industrial users. ANON. *Brick Clay Rec.*, **76** [12], 780–82 (1930).—For firing conditions, such as are present in the clay products industry, where cleanliness, furnace atmosphere, and temperature control are important factors in obtaining quality products, butane has been proposed as a satisfactory fuel. Commercial butane, which is a mixture of normal butane and iso-butane with very small percentages of propane and pentanes, has established its value as a gaseous fuel for many industrial operations. This fuel is available in all districts as it is loaded at the producer's plant storage into tank cars in which it is shipped as a liquid under vapor pressure to the industrial plant where it is to be used. One gallon of liquid gas is equivalent in thermal value to 193.2 cu. ft. of 530 B.t.u. gas. Butane comes in liquid form and before being used in service is returned to its gaseous form through vaporization. The Philfuels Co., Detroit, Mich., supplies butane for domestic and industrial application. Its industrial gas is known as G-4 Philfuel. An important use for G-4 Philfuel is as a standby or auxiliary fuel to natural gas. Data on commercial butane and comparative figures are presented. E.J.V.

Philfuels process of gas manufacture. G. L. BRENNAN. *Gas Age-Rec.*, **65** [23], 845–46 (1930).—The rapidly increasing supply of liquefied petroleum gas has become a new factor in America's fuel markets and of the many phases of utilization of these products probably that of greatest interest is the use of commerical butane for the direct manufacture of city gas by means of the Philfuels process. The gas produced by this method is a mixture of air and butane vapor in proper proportions to give a gas of the desired calorific value. Detailed data regarding the process and equipment needed therein are given. Illustrated. E.J.V.

Heat content of flue gas. P. W. ANDERSON. *Power*, **71** [23], 914–15 (1930).—A general equation for the heat content, Q, above 32°F, of any substance at a temperature t_1 may be written $Q = Mc(t_1 - 32)$, in which M is the weight of the substance and c, its specific heat. A curve showing the heat content of gas at 15% CO_2 was prepared by calculating the heat content at various points between 212°F and 3000°F. H.W.A.

Determining air supply when burning natural gas. ERIK PICK. *Power*, **71** [7], 256–58 (1930).—Measurement of carbon monoxide, difficult at best, is not a safe indication of the loss due to incomplete combustion when burning natural gas. It has been found that with this fuel, a CO_2 recorder operating on the density principle will automatically indicate a deficiency of air as well as an excess and that the best efficiency is obtained at the point of highest reading. H.W.A.

Selection of coal for gas producers. E. J. C. BOWMAKER AND J. D. CAUWOOD. *Jour. Soc. Glass Tech.*, **14** [53], 16–30 (1930).—A set of standard tests for producer-gas coal evolved by the authors is described. Proximate analysis was first performed on each sample. Lignites are successfully used, and anthracite and coke are occasionally used for special purposes, but the bulk of coal used in England for the manufacture of producer gas is bituminous. The authors were definitely interested in the selection of coal for Kerpely gas producers, with 10-ft. diameter grates, automatic feed, and ash

removal, but hand-poked. The coal required was one for steady gasification at the rate of 20 cwt. per hour and capable of being gasified for short peakloads at 25 cwt. per hour. Coals containing 35 to 38% "volatile matter" are the most suitable. Two methods used to test the coking properties were (1) heating ground-up samples in various ways and at various rates and different temperatures, and (2) working with organic solvents. Aniline solubilities varied from 1.7 to 16.4% in the range of bituminous coals, and when these coals were arranged in order of least soluble to most soluble, the series was almost identical with the least caking to most caking in producer performance. Solubility should not exceed 6%. The temperature of fusion of coal ash pyramids was found to depend upon (1) the rate of heating and (2) the per cent of reducing or oxidizing gases present in the atmosphere. The ash should not exceed 5% of the dry coal. The amount of ferric oxide should not exceed 15% of the ash. G.R.S.

Combustion of pulverized fuel. A. L. GODBERT. *Fuel Sci. Practice*, **9** [2], 57–74 (1930).—To burn powdered coal in the plant most efficiently and expeditiously it is of greatest importance that the intensity of combustion should be raised to its maximum value so as to reduce the size of the installation and the capital costs. The ignition space can be reduced by (1) preheating the air for combustion, (2) injecting the dust into the furnace at as low a speed as possible, and (3) supplying the minimum amount of air to the dust at the burner to suspend it, thus reducing its thermal capacity, and injecting the combustion air into the cloud at a point where its temperature has been raised to the proper degree by the heat of the furnace. A high thermal intensity depends more on the rate of contact between the oxygen of the air and the dust particles than upon the reactivity of the dust. Relative motion between the dust particles accelerates the rate of combustion by sweeping away the products of combustion from the surface of the dust, thus exposing it to the fresh oxygen. Much of the practical work has been concentrated on increasing this relative movement, *e.g.*, by imparting "turbulence" to the dust cloud by means of a special type of burner or by a special mode of firing the dust. A high temperature of the combustion space favors a high rate of combustion and facilitates the ignition of the dust as it enters the furnace. See also *Ceram. Abs.*, **9** [7], 560 (1930). R.G.M.

Simplifying ash, volatile, and fixed carbon determinations. M. L. BURDEN. *Power*, **71** [23], 911 (1930).—A complete chart is constructed to save time in making the various calculations necessary to put the ash, volatile, and fixed carbon in coal on a "dry" and "as-received" basis. Sample calculations are given. H.W.A.

Systematic studies on the behavior of soluble salts in clays during firing. A. SIMON AND K. SCHMIDER. *Z. angew. Chem.*, **43** [19], 380–82 (1930); for abstract see *Ceram. Abs.*, **9** [8], 666 (1930). L.T.B.

Submerged combustion. ANON. *Can. Chem. Met.*, **14** [6], 40 (1930).—One of the most interesting new industrial developments is submerged combustion, *i.e.*, burning a flame under water or other liquid, using at the burner gas, oil, or other liquid fuel, or pulverized solid fuel. The "Hammond" burner equipment is of the most ingenious character, the basic principles involved being the supply of the air and fuel under pressure in exactly the theoretical proportion, using an extremely accurate proportioning valve to attain this object; a mixing chamber on entirely new lines, having a whole series of small pressure jets of air and fuel to give an intimate and almost instantaneous mixing; and a burner proper, lined with the refractory material, Alundel, the burner being below the surface of the liquid. The amount of heat generated at the burner is enormous, calculated as 20,000,000 B.t.u. given out per hour for every cubic foot of combustion space, about 200 times the weight of ordinary solid fuel and forced draft firing, while the center of the flame is stated to reach 5432°F (3000°C). Illustrated. E.J.V.

Determination of calorific values of liquid and gaseous fuels. ANON. *Wärme Kälte Technik.*, **32** [5], 4–6 (1930); *Trans. Amer. Soc. Steel Treating*, **17** [6], 892 (1930).—A brief discussion of the methods and their reliability are given together with precautions to be observed in measuring calorific values of liquid and gaseous fuels. E.P.R.

Production and combustion of gas. T. J. ESS. *Blast Fur. Steel Plant*, **18** [5], 789–95 (1930).—Considered from a theoretical standpoint, the most economical method of coal utilization is by direct firing. The ease of regulation and nicety with which combustion can be controlled in gas burning usually results in increased efficiency if coal is first gasified. In general practice, producer gas is made by passing a mixture of steam and air through a hot bed of coal or coke. The oxygen of the air burns the coal to CO_2, liberating heat, and raising the temperature of the fuel bed. Further contact between the CO_2 and the hot fuel bed tends to reduce the CO_2 to CO. The moisture from the steam brought in by the blast reacts with the hot carbon to form H_2, CO, and CO_2. The hot gases rising on through the green coal at the top drive off volatile matter of the coal in the form of hydrocarbons. Fuel bed conditions, coal characteristics, fuel charging, blast supply, producer capacity, and operation are discussed. Operating costs and producer calculations are outlined. As producer gas is a comparatively lean gas, and has a correspondingly low temperature of combustion, it is necessary that the gas be preheated for high-temperature work. Illustrated. E.J.V.

Loss in coking quality of coal. ANON. *Gas Age-Rec.*, **65** [20], 740 (1930).—As a general rule, coals initially high in oxygen absorb more oxygen readily, and if they initially possess coking qualities the coking strength is reduced upon exposure in storage. Such changes are particularly pronounced with high-oxygen coals which are near the border line between coking and noncoking coals. Experiments conducted on three coals of this character showed that the agglutinating value of two of the coals dropped from approximately 3500 to 850 during the first two months, while the third showed a drop from 3700 to 2500 in a similar period. The most significant change noted in the coals was the increase in oxygen content after exposure. E.J.V.

Nomograms for flue-gas analysis. R. SCHUMACHER. *Werft-Reederei-Hafen*, **10**, 350–52 (1929).—Requisite formulas lend themselves to nomographic presentation, and 2 convenient nomograms are published. Diagrams are recommended for use on shipboard in conjunction with a CO_2 meter. See also *Ceram. Abs.*, **9** [7], 563 (1930). (*C.A.*)

Commercially defined combustion efficiency. W. D. WYLDE. *Cassier's Mech. Handling*, **17** [1], 25–26 (1930); *Trans. Amer. Soc. Steel Treating*, **17** [6], 893 (1930).—A comparative discussion of the theoretical and actual fuel combustion efficiency is given together with the effect of varying air supplies upon fuel combustion. Tables illustrating maximum percentage of carbon dioxide obtainable under various conditions are included. E.P.R.

Fuel economy in clay industry. C. LANGE. *Tonind.-Ztg.*, **54** [39], 655–57; [42], 706–707 (1930).—When mineral coal is stored 12 months out-of-doors, it undergoes a 2 to 3% loss of heat, the origin of which can be ascribed to a loss of carbon (2 to 4%), and hydrogen (1.5 to 2%). The gas contained by mineral coal begins to escape and mechanical changes take place which decrease the solidity (12 to 24%), and generate frictional electricity, causing the reduction of the capability of resisting chemical changes. The most advantageous method of preventing the destruction of coal seems to be to store it in small piles under a roof. A roof is necessary as rain water contains ozone which oxidizes coal, and water decomposes iron pyrite into ferrous oxide. The piles must not be higher than 2.5 m. and should be used as soon as possible. Carbon dioxide is the best agent to extinguish coal fires. Salt solutions are also good. A really efficient method of extinguishing coal fires should include chemical agents to

prevent the explosion of gases and to exclude oxygen, water as a cooling agent, removal of the partially burned coal, the interior of which may still be undergoing oxidation after the fire has been apparently extinguished. M.V.K.

Production and distribution of natural gas. G. R. HOPKINS. *Ind. Eng. Chem.*, **22** [5], 502–508 (1930).—H. discusses composition, producing fields, reserves, market, line-construction, uses, competition with other fuels, control of industry gas rates, and conservation. A map of the U.S. showing principal natural-gas lines is included. The article is a complete and comprehensive survey of the natural gas situation. R.G.M.

Measurement of radiant heat. F. E. VANDAVEER. *Ind. Eng. Chem.*, **22** [6], 596–600 (1930).—The thermopile and its calibration, the method of testing radiant heaters for radiant efficiency used at the American Gas Assn. Testing Lab. are described in detail. It is shown that (1) the thermopile is capable of measuring radiant heat as emitted by a radiant heater; (2) the method of test is capable of giving an accuracy within 1% of the true reading; and (3) the diathermacy constant obtained is consistent and may be accurately obtained. Several means of increasing the total radiant heat are given, as well as a discussion of possibilities of future research along this line. R.G.M.

Heat of combustion of carbon. W. B. PLUMMER. *Ind. Eng. Chem.*, **22** [6], 630–32 (1930).—By degasifying various types of carbons in vacuum at 1000°C, and maintaining the samples in vacuum throughout the cooling and weighing operations, heats of combustion appreciably higher than any previously reported in literature are obtained. The value found for an amorphous carbon is 8272 cal. per g., while a pure graphite gave 7932 cal. per g. which are, respectively, 1.5% and 0.9% higher than previous values. R.G.M.

Recent developments in fuel technology. R. WIGGINTON. *Fuel Sci. Practice*, **8** [9], 409–10 (1929). R.G.M.

Burning out producer-gas mains. L. M. WILSON. *Fuel Sci. Practice*, **8** [10], 472 (1929).—Plenty of chimney draft should be available for a satisfactory burnout of producer-gas flues. No part of the system should be laid out so that a direct current of air either from the producers to the stack or from a furnace to the stack does not pass through it. Every gas flue supplying the furnace should be provided with an off-take which opens into the stack belonging to the same furnace. All valves other than those actually on the producers and furnace regulating valves should be of the water-seal pattern. A complete description of the proper method of burning out is given. R.G.M.

Chemical constitution of coal. J. P. SHOHAN. *Fuel Sci. Practice*, **9** [3], 140–45 (1930); for abstract see *Ceram. Abs.*, **9** [3], 222 (1930). R.G.M.

Researches on inflammation temperatures of solid fuels. SWIETOSLAWSKI, B. ROGA, AND M. CHORAZY. *Fuel Sci. Practice*, **9** [2], 93–96 (1930).—A brief account is given of researches carried out at the Varsovie Chemical Research Institute, in the fuel section, on the inflammation temperature of solid fuels. R.G.M.

Methods of calculating the calorific value of solid fuels. P. JARRIER. *Fuel Sci. Practice*, **8** [10], 486–91 (1929); for abstract see *Ceram. Abs.*, **9** [2], 122 (1930). R.G.M.

Classification of North American coals. A. C. FIELDNER. *Fuel Sci. Practice*, **8** [10], 473–81 (1929); for abstract see *Ceram. Abs.*, **8** [5], 354 (1929). R.G.M.

Specific surface reaction rate of pure carbon in air. ANON. *Gas Age-Rec.*, **65** [24], 900 (1930).—The specific surface reaction of pure carbon in air has been measured with remarkable reproductibility by scientific workers. This information is important in the burning of solid fuels such as coal and coke. Fundamental information on this

chemical reaction has been difficult to obtain because of the difficulty of adequately controlling the important factors of oxygen concentration, area of reacting surface, and surface temperature. When a piece of carbon starts to burn vigorously the surface area changes rapidly, the surface temperature quickly gets out of hand, and the concentration of available oxygen rapidly decreases. The new method involves bringing accurately shaped and weighed spheres of carbon to a known temperature in an inert gas, suddenly blasting the particle with an air stream of known velocity and temperature for a very short interval, quickly quenching the particle in inert gas, again weighing to determine the amount of reaction and obtaining careful records of the particle surface temperature during the combustion. The results are highly reproducible and should be of real value in the design of coal- and coke-burning installations.

E.J.V.

Dustless coke preparation. R. E. FULREADER. *Gas Age-Rec.*, **65** [21], 780 (1930).—One of the characteristics most objectionable to all solid fuels is the presence of dust. The Rochester Gas & Electric Corp. has produced a dustless coke by spraying the coke with a solution containing 18% by weight of calcium chloride, using approximately 3 gal. of the solution per ton of coke. There is no change in the fusion point of the treated coke, and the increase in the ash content amounts to only 5 lb. per T. The process and equipment used are described. E.J.V.

Influence of coke reactivity on water-gas production. K. BUNTE AND A. GIESSEN. *Gas und Wasserfach*, pp. 241–47 (1930); *Gas Age-Rec.*, **65** [19], 682; [25], 936 (1930).—Experimental results are presented which indicate that the reactivity of various cokes with respect to water vapor decreases in the following order: wet-quenched, low-temperature, lignite coke; wood charcoal; dry-quenched, low-temperature lignite-coke; semicoke; wet-quenched gas coke; dry-quenched gas coke, and oven coke. This is in the same order as determined for O_2 alone and O_2 and CO_2. Some relationship can be noted between water-vapor decomposition and ignition temperature of the coke, but this is obscured by the effect of undecomposed steam through the fuel bed on the water-gas equilibrium in the gaseous phase. This effect is difficult to evaluate as it is practically impossible to draw gas samples directly from the fuel surface, and, in addition, equilibrium is not reached in the water-gas reaction, even at the higher temperatures. E.J.V.

Cracking natural gas in water-gas generators. W. W. ODELL. *Gas Age-Rec.*, **65** [20], 719–23 (1930).—Tests on the experimental cracking of natural gas in a water-gas generator were made in order to obtain data relating to large-scale operation and operating results, including the determination of (1) quantity of carbon recoverable and its properties, (2) fuel requirements, (3) effect of certain changes in operating procedure upon results, and (4) composition of the recovered (cracked) gas. An outline of the procedure followed. The theoretical considerations involved, operation, and observed results are given. Observations were made of the temperature zones in the fuel bed, the appearance of coke removed from the base of the generator, fuel (coke) consumption, gas and carbon yields, increasing thermal efficiency, quality of the recovered carbon black, and the removal of carbon from gas. The general conclusions drawn from this investigation are (1) natural gas can be cracked in a water-gas generator by making alternate air blasts and gas runs. The resultant gas is comprised largely of hydrogen. (2) The gas produced may be used as follows: (*a*) mixed in small percentage with natural gas and used in place of the latter; (*b*) carburetted and mixed in small percentage with natural gas or used straight as manufactured gas for city distribution; (*c*) mixed with natural and water gas, with varying amounts of blow-run gas (varying under control) and distributed as city gas; (*d*) used as a source of hydrogen for making synthetic materials such as ammonia or for other industrial purposes;

and (*e*) mixed with water gas in amounts required to give the CO:H_2 ratio desired in making methanol or other products. (3) Carbon black can be recovered in making hydrogen gas in amounts approximating 7 lb. per 1000 cu. ft. of natural gas cracked. (4) The amount of solid fuel used in the process chargeable to the cracking operation is less when some water gas is made than when making only air blasts and gas runs. This is true whether the water gas is made simultaneously with the cracked gas or in alternate straight water-gas runs. (5) A large amount of generator fuel was used in the tests in cracking natural gas by making alternate air blasts and gas runs. It is recognized that with continuous operation (the tests were of short duration) improvments in operating technique, and possibly some changes in procedure, the amount of fuel required for cracking a unit volume of natural gas might be materially reduced. (6) The process is worthy of further study and, if a reasonable high price can be obtained for the carbon black, it should be developed. Illustrated. E.J.V.

Burning of various solid fuels. ANON. *Gas Age-Rec.*, **66** [1], 27 (1930).—Interest in smokeless fuels has centered attention on the relative burning characteristics of cokes made by the various high- and low-temperature processes. Recently data have been published on the time of burning of small particles of coal, semicoke, beehive coke, and charcoal under controllable conditions of furnace temperature, particle size, and oxygen concentration. Through the use of fuel particles weighing 4 mg. it has been possible to follow the temperature of the particle throughout its burning. The maximum temperature of an individual particle burning in an excess of air at 800°C is much below the temperature obtainable in a fuel bed. The interesting part of the temperature curve of the burning is the form the curve takes under different conditions. When the air temperature is 800°C, the rate of rise of the particle temperature above the air temperature is so slow and variable that it is nearly impossible to assign a definite point as the "start" of ignition or active burning. Likewise, the point of completion of burning is often prolonged. With air at 1000°C the rate of rise and decline of temperature is very rapid. These effects vary with the nature of the fuel, being most pronounced for a material like electrode carbon. Therefore, strict comparisons of the burning times of many fuels by this method at lower air temperatures are not possible. E.J.V.

Strength of coke made from gas coals. ANON. *Gas Age-Rec.*, **66** [1], 22 (1930).—Work on the gas and coke-making properties of American coals is now in progress at the Pittsburgh Station, U. S. Bureau of Mines, in coöperation with the American Gas Assn. Apparatus has been standardized for testing coal in 80- to 90-lb. charges as to the yield and quality of gas and coke obtainable therefrom. Tests now complete for representative gas coals (unmixed with lower volatile coals) clearly show that cokes made at carbonization temperatures 500 to 900°C are considerably stronger than those made at higher temperatures. The methods used for determining the strength of the coke are the shatter and tumbler tests as standardized by the A.S.T.M. The fact that these coals were unmixed with a low-volatile coking coal is emphasized, because such mixing is known by coke-oven engineers to greatly improve the strength of high-temperature coke. E.J.V.

Standard shatter test for coke. ANON. *Blast Fur. Steel Plant*, **18** [7], 1157–58 (1930).—Details of the standard method for the shatter test adopted and advocated by the Midland, Northern, and Scottish Coke Research Committees, are given. Illustrated. E.J.V.

BOOKS AND BULLETINS

Ceramic Kilns. DENVER FIRE CLAY CO. *Brick Clay Rec.*, **77** [1], 50 (1930).—In addition to a treatise on elementary ceramic procedure by Hewitt Wilson, the booklet

contains descriptions and illustrations of styles of laboratory and studio-size kilns. It also describes Denver Fire Clay's oil and gas kiln burners, clay-testing furnace, and motor blowers. E.J.V.

Industrial Furnace Technique. A. HERMANSEN. Translated from the Swedish and published by Ernest Benn, Ltd., London. 293 pp. Price 25s. Reviewed in *Gas Age-Rec.*, **65** [23], 854 (1930); see also *Ceram. Abs.*, **9** [5], 373 (1930). E.J.V.

Heat Loss Analysis. E. A. UEHLING. McGraw-Hill Book Co., N. Y. 241 pp. Price $2.50. Reviewed in *Mining and Met.*, **11** [282], 22 (1930).—The heating value of the amount of coal that contains a pound of carbon is the same, within practical limits, for all coals of the same type. U. has developed simple formulas for calculating and analyzing the heat losses in a boiler plant. This book explains in simple language the processes of combustion and heat absorption, shows how the recorded data can be resolved into the corresponding heat losses, and describes methods for applying the results to control operations. E.J.V.

Gaseous Combustion at High Pressures. WILLIAM A. BONE, DUDLEY M. NEWITT, AND DONALD T. A. TOWNSEND. Longmans, Green & Co., London and New York. 396 pp. Price $15.00. Reviewed in *Mining and Met.*, **11** [282], 22 (1930); *Engineering*, **129** [3355], 561(1930).—This book completes the review of the principal researches on flame and combustion from the time of Robert Boyle to the present which was begun with their "Flame and Combustion in Gases," published two years ago (see *Ceram. Abs.*, **7** [2], 100 (1928)). It is chiefly concerned with the researches that have been carried out during the past 20 years by Bone and his collaborators. That work comprised the study of hydrogen-air, carbonic oxide-air, and methane-air explosions at initial pressures between 3 and 175 atmospheres, with the development of suitable apparatus for the investigation. A bibliography and a summary of the principal data relating to compressibilities of gases are appended. E.J.V.

Scottish Coking and Furnace Coals. THOMAS GRAY, T. H. P. HERIOT, AND W. J. SKILLING. H. M. Stationery Office. Price 4s net. Reviewed in *Colliery Guardian*, **140** [3623], 2150 (1930).—This report deals with the methods of sampling, analyzing, and testing, and G.'s suggestion regarding the use of narrower coke ovens and higher carbonizing temperatures for the production of serviceable coke from lower-grade coals has since been widely adopted. Part II of the report contains the proximate analyses, with sulphur and phosphorus content, coking index, and bag test of 367 coals arranged geographically in groups. In Part III, a description is given of each seam in ascending order in the sequence, correlation being indicated where necessary. The report is accompanied by a colored map showing the different coal fields and comparative vertical sections of the limestone series and productive coal measures. E.J.V.

Sulphur in Coal. (Kohlenschwefel.) F. MÜHLERT. W. Knapp, Halle, 1930. 139 pp., 28 illustrations. Price Rm 15.50. Reviewed in *Stahl Eisen*, **50** [25], 903 (1930).—M. describes deposits of coal and different minerals containing sulphuric acid, and other forms of sulphur. Different methods for determining and removing it are discussed. The injurious effects of sulphuric acid in the glass, clay, and iron industries are treated. M.V.K.

Influence of washing coal on coke properties and on gas and by-product yields. A. C. FIELDNER. Bur. Mines, *Rept. of Invest.*, No. 3020, 13 pp. (May, 1930); *Blast Fur. Steel Plant*, **18** [7], 1139–42 (1930).—In considering the use of washed coal, the gas or coke plant operator is concerned with two classes of effects, *viz.*, those due to the removal of free mineral constituents such as slate, shale, bone, and pyrite and those due to the surface moisture left in the coal from the washery. All of the first class are desirable, as they improve the quality of the carbonization products. The second

class of effects, those due to moisture, are complex, partly desirable, but mostly undesirable, especially with a material increase of moisture in the coal. The favorable effects of eliminating free mineral impurities may be summarized as follows: (1) improvement of coke quality: (*a*) reduction of ash and sulphur, (*b*) less clinker trouble, (*c*) fewer cross-fractures in coke, resulting in greater resistance on handling, less small coke and breeze, and (*d*) greater uniformity in chemical composition and physical properties of coke; (2) less sulphur in gas; (3) greater yield of gas and by-products per ton of dry coal charged. The adverse effects of moisture are (1) reduction of oven capacity and throughput, due to lower charging density of moist coal, and longer time required to complete coking at a given temperature; (2) higher fuel consumption per ton of coal carbonized; (3) nonuniform coke, due to wet spots in charge; (4) excessive moisture (12 to 15%, causes large-celled, weak coke); (5) dripping wet coal may cause spalling of the brick-oven lining. Moisture increases the ammonia yield and reduces carbon deposits on the oven walls. On the whole it seems certain that the moisture should be kept low (less than 5%) for the most economical results.

R.A.H.

PATENTS

Kiln bottom. LEE DELL S. KLOTZ. U. S. 1,764,025, June 17, 1930. A downdraft kiln provided with perforate floor, downwardly and inwardly inclined side walls beneath the floor, spaced walls beneath the floor and abutting the side walls forming transverse flues between the walls unrestricted throughout the length and breadth of the walls, the spaced walls having aligned openings in their lower portions forming an exit flue freely communicating with the transverse flues, the downwardly and inwardly inclined walls terminating at their lower ends at points spaced laterally from the aligned openings in the spaced walls, and an outlet communicating with the exit flue.

Terminal. JAMES KELLEHER. U. S. 1,764,045, June 17, 1930. An electric terminal for use in an electric resistor furnace comprising a carbonaceous inner block secured to the resistor of the furnace, an outer carbonaceous block within the walls of the furnace, a water-cooling means extending through the walls of the furnace for cooling the outer block, a carbonaceous rod of relatively small cross-sectional area secured at each end to the blocks and a refractory coating for sealing the outer block and rod within the walls of the furnace adapted to become plastic without melting at the temperature at which oxidation of the rod begins.

Method of making resistor material. MARSDEN H. HUNT. U. S. 1,764,311, June 17, 1930. A method of preparing resistor material which comprises grinding a mixture of a conducting and nonconducting substance, a plastic clay and a silicate glass that fuses at a temperature below 900°C thoroughly together, forming the mass into the shape of a resistor, drying the formed body at a temperature of about 150°C, and then firing the dried body at a temperature between 500°C and 900°C.

Tunnel kiln. PAUL A. MEEHAN. U. S. 1,764,460, June 17, 1930. A tunnel kiln having a kiln chamber therein for the passage of ware-carrying cars therethrough, a preheating section, a longitudinally extending chamber in the side wall of the preheating section, means for passing heating gases through the wall chamber, and separate means providing a positive circulation of the kiln atmosphere in the preheating section through the wall chamber out of direct contact with the heating gases whereby the atmosphere absorbs heat from the heating gases therein.

Retort for distilling oil shale, etc. MAGNUS RUDOLF KRAUL. U. S. 1,766,132, June 24, 1930. In a retort, the combination of a vertical rectangular enclosure comprising walls on two sides and one end, longitudinal walls within the enclosure arranged to divide the same into a central elongate distilling chamber and a heating chamber

on each side of the distilling chamber, heating means located in each heating chamber, wall sections closing the other ends of the heating chambers, and removable wall plates secured to the wall sections closing the same end of the distilling chamber, a rectangular elongate frame in the distilling chamber, the frame comprising two opposite spaced sides each supporting a series of vertically spaced horizontal shelves extending inward midway of the distilling chamber and sloping downward, with the shelves of one series arranged in staggered relationship with those of the other, to hold layers of the material being retorted and, to feed the same from an upper shelf onto a lower, the frame being of lesser length horizontally than the distilling chamber thereby to provide a gas-collecting chamber, at one end within the latter, spaces under the shelves adapted to constitute gas-collecting sheds and passageways and which open into the gas-collecting chamber, the latter chamber adapted to be connected to gas withdrawing means.

Rotary kiln. ROBERT D. PIKE. U. S. 1,766,453, June 24, 1930. An inclined rotary kiln having a diametrically enlarged section at the upper end thereof divided into a plurality of longitudinally extending open-ended passageways, the passageways being outlined by radially and circumferentially extending partitions of corrugated metal having a high heat conductivity and a high degree of heat resistance.

Burner for hard fuel. ANDREW O. JACKSON. U. S. 1,766,641, June 24, 1930. A burner having an upright fuel magazine and having an outwardly sloping floor each of which is vertically movable independently of the other and having a perforated grate around the floor between which and the floor, fuel falling from the magazine can be burned and means for controlling the supply of air through the perforated grate into the combustion area.

Regulation of furnace electrodes. GOTTLIEB KELLER. U. S. 1,766,648, June 24, 1930. In an electric furnace, the combination with a movable electrode carrier and an electrode mounted thereon, of a power cylinder for controlling the position of the carrier, a regulating device responsive to variations in the electrical power taken by the electrode for regulating flow of liquid under pressure to and from the cylinder, and a throttling device in the supply line between the power cylinder and regulating device, the throttling device opening under pressure of liquid flowing to the power cylinder and partially closing under pressure of liquid flowing from the power cylinder.

Burning pulverized fuel. FRITZ KOCH. U. S. 1,766,652, June 24, 1930. A furnace for burning pulverized fuel, comprising a combustion chamber having downwardly converging spaced side walls, a fuel-supporting grate connecting the lower portion of the side walls, fuel-feeding means for the grate, and air-blast means disposed below the grate for agitating and depositing a portion of the fuel upon the side walls of the combustion chamber whereby the fuel is moved by gravity toward the grate and in the path of the air blast in continually recurring cycles until consumed.

Resistor grid. FRANK T. COPE. U. S. 1,767,171, June 24, 1930. A resistor heating grid formed of a bar of substantial thickness of substantially channel-shaped, cross-sectional shape, bent upon itself to provide a plurality of vertical parallel portions connected at alternate ends by curved portions.

Method of supporting resistor grid. FRANK T. COPE. U. S. 1,767,172, June 24, 1930. A grid formed of a bar of substantially T-shaped, cross-sectional shape, bent upon itself to provide a plurality of vertical parallel portions connected at alternate ends by curved portions, the curved portions at the upper end of the grid being of substantially flat cross-sectional shape and supporting hooks engaging the upper curved portions.

Firing kiln. GEORGE HENRY GARRISON. U. S. 1,767,281, June 24, 1930. Means for mounting a firearm on a firing kiln comprising a yoke having ends which encircle the barrel of the firearm, and a recoil spring abutting one of the ends.

Electrical heating unit. HAROLD N. SHAW. U. S. 1,767,816, June 24, 1930. In an electrical heating device, the combination of an insulating support having a plurality of circuit terminals concentrically arranged thereon, a recessed contact element mounted at one end of the support, a self-sustaining heating element having one terminal thereof in engagement with the recessed contact portion, a second contact element disposed at a point remote from the support and in axial alignment therewith, and yielding supporting means for the second contact, the supporting means comprising a plurality of spaced arms associated with the second contact and mounted upon the plug through the intermediary of a securing bolt arranged substantially axially of the support.

Furnace. ALBERT W. SMITH AND RICHARD B. JONES. U. S. 1,767,817, June 24, 1930. The method which consists in conducting gas into the port of a furnace and conducting air into the region of the port and subjecting the air therein to a transverse gaseous current to direct the air into the port and mix it and the gas together and to a longitudinal current for conducting the mixture into a combustion and heating chamber.

Method of operating continuous car-tunnel furnace. DANA P. OGDEN. U. S. 1,768,486, June 24, 1930. A heat-treating mechanism comprising a chamber for containing material to be treated, means for moving the material in one direction through the chamber, means for drawing gases over the material in the opposite direction through the chamber, means at a portion intermediate the length of the chamber for heating the material, and means at either end of the portion for effecting a lateral circulation of the gases.

Heating element-mounting construction. EDWIN L. SMALLEY. U. S. 1,768,865, July 1, 1930. Means for mounting resistance elements within a furnace structure comprising a plurality of refractory members extending from a furnace wall, the refractory member having a plurality of laterally extending fluted portions, a heat-reflecting member secured between the fluted portions of adjacent refractory members, the heat-reflecting member having a plurality of corrugations along the surface thereof, a resistor element having a plurality of turns, the turns being disposed in the corrugations in the heat-reflecting member, and having portions thereof extending beneath the fluted edges of the refractories, whereby the turns are maintained in position with respect to the heat-reflecting member.

Induction furnace. PORTER H. BRACE. U. S. 1,768,881, July 1, 1930. In an electric heating device including a crucible and a helical energizing coil surrounding it, means in the crucible coöperating therewith to provide a plurality of substantially separate secondary electric circuits in a mass of material located in the crucible.

Coking process. C. B. WATSON AND R. H. CARR. Brit. 323,829, March 5, 1930. *Gas Age-Rec.*, **65** [22], 829 (1930).—The process has for its purpose the production of low-temperature coke by subjecting an upwardly moving body of coal to temperatures of 650 to 1000°F by means of a counter-current of gaseous heating medium, such as steam or oil vapor. The apparatus consists of a closed chamber, a fuel feed device, which may also include a hopper, a ram and a nozzle, and a vertical rotating shaft carrying midway of its length a conveyer blade, and near the top a number of radiating arms supporting a ring with depending tines. The coke is extruded through an outlet near the top of the chamber provided with a spiral blade conveyer.

E.J.V.

Distilling coal. W. E. TRENT. Brit. 325,324, April 9, 1930; *Gas Age-Rec.*, **65** [22], 830 (1930).—Solid carbonaceous materials are distilled or gasified by being heated by heat conductors such as metallic rods to which heat is applied at points away from those at which contact with the material takes place. These metal rods extend through the heating chambers and retorts. They support trays with perforated bottoms in which the coal is placed. The apparatus may be operated as a gas producer in which

case air or steam may be introduced; the perforated bottoms of the trays permit gases to circulate through the charge. E.J.V.

Manufacture of gas. ILLINGWORTH CARBONIZATION CO., LTD., AND S. R. ILLINGWORTH. Brit. 326,135, April 30, 1930; *Gas Age-Rec.*, **65** [26], 983 (1930).—The distillates from coal heated in a retort to about 600°C are passed through coke in a chamber heated to about 700°C or over. The volatiles are thereby transformed into light hydrocarbons. The retorts are built up of H-section plates, and fed through pipes. The volatiles pass through a duct to the lower end of the coke chamber. Air may be admitted to heat the coke by combustion and to generate producer gas. The water vapor in the gases is converted into producer gas or water gas and free ammonia from which ammonium sulphate may be directly obtained. The phenols are converted into light hydrocarbons of the benzene group. E.J.V.

Tunnel kiln trucks. H. M. ROBERTSON. Brit. 328,264, June 18, 1930. A truck, adapted particularly for use in tunnel kilns, comprises a metal frame with depending plates forming bearings for the wheel axles and a base portion of refractory brick, the upper surface of which is inclined downwardly from each side toward the center line of the truck to form surfaces on which rest spaced rows of blocks supporting the slabs which form the actual work holder. The blocks and slabs are all formed of refractory material. The opposite ends of the base portion are provided, at different levels, with projecting ribs which overlap when a train of trucks is being moved through the kiln, and prevent downward passage of heat to the wheels, axles, and bearings. A modification is described in which end walls of refractory material are provided, while in a further construction refractory side walls are supported on the outer edges of the side slabs which, in this case, are only slightly inclined.

Tunnel kilns. H. M. ROBERTSON. Brit. 328,265, June 18, 1930. In a tunnel kiln for calcining limestone, shale, etc., having preheating, firing, and cooling zones there are arranged on each side of the firing zone a number of primary combustion chambers, fired by liquid, gaseous, or solid fuel and communicating with a single secondary combustion chamber which is supplied at its lower part with air heated in passages below the chambers. The secondary combustion chambers are formed with refractory top and rear walls and a front wall perforated for the passage of the hot gases into the kiln. A suction fan is provided in the chimney for withdrawing the waste gases and the vapors evolved from the charge through one or more of a number of regulatable roof apertures which communicate with a longitudinal flue connected by a conduit with the chimney. Additional waste-gas outlets are provided in the outer members of a series of baffle elements spaced along the side walls of the preheating zone, the rear wall of these elements being formed with a number of inlets leading to separate vertical pipes which deliver at their lower ends to waste-gas flues.

Gasification of coking coal in a gas producer. K. KOLLER. Ger. 479,030; *Gas Age-Rec.*, **65** [22], 830 (1930).—The feature of this apparatus is the rotary carbonization retort with which it is provided. This retort has a circular cross-section at the top and a noncircular cross-section at the bottom. The operation of the gas producer, in which the blow gas passes through the carbonizing retort, is carried out in such a manner with accurate control of the temperature that the coking zone is maintained at the section separating the column of fuel maintained in rotation by the rotating carbonizing retort and the part of the fuel bed maintained at rest in the producer. E.J.V.

Gas-fired annular kiln for ceramic materials. HERMANN LEGLER. Ger. 495,318, June 13, 1926. (*C.A.*)

Tunnel kiln. KERAMISCHE INDUSTRIE-BEDARFS-A.-G. Ger. 496,391, Jan. 31, 1928. Addn. to 431,856. (*C.A.*)

Coal gas manufacture. R. RUEBLING AND R. MEZGER. Ger. 480,489; *Gas Age-Rec.*, **65** [22], 830 (1930).—The process of manufacturing the gas consists in the alternate production of coal gas and water gas. The carbonization of the coal is accomplished by means of the water gas which is made to pass through the bed of coal. The carbonizing portion of the apparatus is the upper part and consists of a column, the walls of which slope so that the widest part of the column is that at which it joins the lower gasification column, while the narrowest part is at the top where the manufactured gas leaves. New fuel is introduced through a double hopper arrangement of the usual sort. At the point where the carbonizing column joins the gasification shaft, which is made with vertical walls, is located a roll, which rotates in such a manner that only as much coke is allowed to move down into the gasification part of the apparatus as is necessary to maintain a section of the apparatus, between the top of the bed of coke in the gasification chamber and the bottom of the hot coke in the carbonizing chamber, free of solid material. This space is provided so that free movement of the gas made in the gasification chamber up and through the carbonizing section is possible. The rotating roll also crushes the coke as it passes down into the gasifier. E.J.V.

Gasification of coke and other combustibles. P. DVORKOVITZ. Ger. 481,174; *Gas Age-Rec.*, **65** [26], 984 (1930).—This apparatus is used for the gasification of coke and other carbonaceous materials in the finely pulverized state. A gas producer is used and superheated steam is blown in. A heat regenerator is connected with the producer, the steam being superheated in this apparatus. The pulverized fuel enters at the top through a funnel-shaped inlet. The flow of pulverized fuel is directed in such a manner that it strikes an impact plate fixed to the wall of the producer and located directly opposite to the steam inlet from the heat regenerator. This results in an intimate mixture of the steam and fuel. E.J.V.

Regenerative coke oven. C. OTTO & CO. Ger. 481,876; *Gas Age-Rec.*, **65** [26], 984 (1930).—This oven can be heated at will with lean gas or high-calorific power gas. It is provided with horizontal oven chambers and with vertical heating flues. The heating flues of a wall are connected with the heating flues of another heating wall over the oven. Two even numbered and two odd numbered heating walls are always considered a pair and each pair of even numbered heating walls with the pair of odd numbered heating walls belonging thereto are considered a heating unit. E.J.V.

Regenerative chamber oven for gas and coke. H. KOPPERS. Ger. 483,282; *Gas Age-Rec.*, **65** [26], 984 (1930).—The chambers may be either horizontal or vertical. The feature of the heating of the coke-oven chambers consists in a suitable time-heating of the chambers from the top to the bottom and from the bottom to the top. Thus gas and air are fed to a portion of the heating flues and only air to another portion in the fuel gas heating arrangement. E.J.V.

Mixture of water gas and coal gas. O. MISCH. Ger. 483,594; *Gas Age-Rec.*, **65** [26], 984 (1930).—This process is concerned with the production of a mixture of water gas and coal gas with a heating value of 3500 to 4500 calories per cu. m. from bituminous fuels. A gas generator is used in the process, to which is connected a shaft, heated by means of short, hot flames, and which is used for the carbonization of the fuel. Water gas is manufactured in a continuous process in the lower portion of the carbonizing shaft and at the same time an uninterrupted flow of air or a mixture of air and steam enters or is blown into the lower part of the shaft. Thus water gas is made for admixture with coal and also a blue gas for heating the carbonizing shaft. E.J.V.

Geology

Problems of the glacialist. FRANK LEVERETT. *Science*, **71** [1829], 47–57 (1930).—Future work of the glacialist is outlined. The topics treated are (1) problem of glacial epochs, (2) worldwide correlations of glacial stages, (3) length of pleistocene glacial and interglacial stages, (4) relation of glaciation to pleistocene diastrophism, (5) the loess problem, (6) relation of man to the glacial epoch, (7) problems of glacial oscillations, (8) origin of drumlins, kames, and eskers, (9) origin of gumbotil, (10) conditions of glacial drainage in the Mississippi basin, and (11) the Iowan drift problem. G.R.S.

Silica distribution and uses. ANON. *Brit. Clayworker*, **38** [453], 388–89 (1930).—Silica, in the form of flint, taught man to associate shape with usefulness, to become an artist and a manufacturer, to be something of a mineralogist and a miner. "Silica-gel," another form of silica, is beginning to be used in one of the most recent developments of scientific industry. This is a preparation of silica, comparable with spongy platinum, consisting of a collection of very minute particles of nearly pure silica, with attendant spandril spaces, the spaces amounting to over 40% of the total bulk. The manufacturers claim that for 1 gram of substance there is no less than 5000 sq. ft. of surface. The uses of silica in construction and industrial processes is briefly referred to. R.A.H.

Diversified mining industries. R. CARL MOORE. *Mfrs. Rec.*, **97** [25], 54–55 (1930).—From a comparatively small area comes approximately one-half of the country's production of crude feldspar, a very large proportion of the output of sheet or dimension mica, the entire production of some other types of mica, and a large proportion of the country's supply of residual kaolin, as well as smaller quantities of asbestos, cyanite, and a number of other minerals either mined alone or occurring as by-products of the mica and feldspar mines. Development of these mining industries has led not only to increased activity in the actual mining field, but it has resulted in an extensive mill-building program during the past two years. A detailed discussion of this area is given. E.P.R.

Polyhalite as a source of potash. ANON. *Can. Chem. Met.*, **14** [6], 16 (1930).—This mineral has been studied recently as a source of potash. It is a sulphate of potash, lime, and magnesia containing 15.6% K_2O. In its crude form, it would be suitable for low-grade potash salt, as it breaks down in water and the potash slowly becomes available depending on the fineness of the material. E.J.V.

China clay. J. E. AITKEN. *Proc. Tech. Sect. Papermakers' Assn.*, **10**, 213–20 (1929).—A popular account of the occurrence, mining, purification, and use of china clay for papermaking. (*B.C.A.*)

Feldspar in 1929. ANON. *Blast Fur. Steel Plant*, **18** [7], 1158 (1930).—Crude feldspar sold or used by producers in the U. S. in 1929 amounted to about 197,699 long T., valued at $1,276,640, or $6.46 a ton. Feldspar was mined and sold in 1929 in 12 states. The greatest feldspar-producing region is that which includes the Atlantic Seaboard States, from Maine to N. C., reporting about 91% of the total quantity and value in 1929. N. C., the leading state, reported about 52% of the total output. E.J.V.

Barite industry and deposits of Missouri. W. M. WEIGEL. Amer. Inst. of Mining and Met. Eng., *Tech. Pub.*, No. 201; *Pit and Quarry*, **18** [13], 87–96 (1929).—Economic deposits of barite occur in Mo. in two main districts. The most important is the southeastern or Washington County district. It embraces about 200,000 acres and accounts for from 80 to 90% of the state production. A complete treatise on the geology and industry of barite is given. E.P.R.

Canadian diatomite development. ANON. *Clay Prod. News*, **3** [6], 12 (1930).—Official government figures are given for the production and importation of diatomite

or kieselguhr in Canada. The method of mining and preparation for market are briefly described. The wide distribution and many uses of diatomite are mentioned. The crude material enters Canada duty-free, while in the partially manufactured state, the general tariff is 17½%. The present price in Canada varies from 30 to $35 per T. for the grade as used in concrete mixtures and up to $150 per T. in small lots for other purposes. W.C.O.W.

Beryllium and beryl in Canada. HUGH S. SPENCE. *Can. Chem. Met.*, **14** [6], 19 (1930).—The Department of Mines, Ottawa, has issued a summary of occurrences of beryllium in Canadian ores, also a description of the metal, and some of the work that has been done on it in the past few years. E.J.V.

Fireclay, kaolin, and silica sand deposits of the Mattagami and Missinaibi rivers. R. J. MONTGOMERY AND R. J. WATSON. *Ontario Dept. Mines*, **37** [Pt. 6], 80–120 (1929).—The clays are (1) surface or glacial and post-glacial clays, including boulder clay or till, stoneless glacial clays, swamp clays, flood-plain silts, and marine clays, and (2) Mesozoic clays, which are much more refractory and include kaolin and fire clays. Kaolin and silica sand occur together, necessitating washing to prepare a pure product. Results of laboratory tests on these products are tabulated. (*C.A.*)

Triassic bentonite of the Painted Desert. VICTOR T. ALLEN. *Amer. Jour. Sci.*, **19** [5], 283–88 (1930).—Gray shales of the lower Chinle formation swell when wet. Their dominant clay mineral is montmorillonite which in some sections preserves a texture of pumice. Soda-sanidine, quartz, biotite, magnetite, apatite, and zircon are also present. An analysis shows: SiO_2 56.40, Al_2O_3 18.86, FeO 0.42, Fe_2O_3 3.36, TiO_2 0.32, CaO 0.90, MgO 1.85, K_2O 1.90, Na_2O 1.50, H_2O at 105° 9.00, H_2O above 105° 5.40%; P_2O_5 and S trace, MnO, Ni, Co, Zn, and CO_2 nil. Relict glass structure, euhedral minerals, presence of sanidine, characteristic chemical and mineralogic composition, waxy luster and swelling in H_2O prove this rock to be formed as a result of volcanic activity. Some portions have products of erosion admixed. (*C.A.*)

Science of geology. H. C. RICHARDS. *Queensland Govt. Mining Jour.*, **31** [5], 215 (1930).—R. in a paper before the Geological Congress in South Africa made a plea for the more extensive application of the science of geology to the mining industry. Even with geophysical methods of prospecting, sound geological work is also necessary. E.P.R.

BULLETINS AND CIRCULARS

Silicates of the types of nepheline and anorthite. GERHARD TRÖMEL. *Rept. Kaiser Wilhelm Inst. Silicate Researches*, Berlin-Dahlem, **3**, 29 pp. (1930).—Syntheses of compounds are described which have a similar composition to nepheline and anorthite and contain rare earth metals instead of alumina. These crystals are characterized optically and röntgenographically. It could be shown that the relationship between nepheline and anorthite is based on the fact that the substitution of sodium by calcium in valence proportions depends on the widening of the oxygen lattice by alumina. M.V.K.

Barite and barium products. II. Barium products. R. M. SANTMYERS. Bur. Mines, *Information Circ.*, No. 6223, 26 pp. (1930).—The preparation of ground barite varies in different plants and according to the condition of the ore. The general practice is to crush the ore to about 1-in. mesh and by log washing to remove the clay and earthy material. The material is then generally ground in a tube mill, and screened or floated to remove coarse particles. The principal use of ground barite is as a filler. The paint, paper, rubber, linoleum, and cloth industries all use considerable quantities to add weight and body to their products. The amount of crude barite used in 1928 amounted to over 330,000 short T. in comparison with 185,000 short T. used in 1918.

The report also discusses market and prices, and imports and exports of ground barite. The basic raw materials necessary for the manufacture of lithopone are crude barite, coal, coke, or petroleum breeze, zinc, and sulphuric acid. A description of the method of manufacture is given. Lithopone is used extensively as a white pigment in flat and enamel wall paints for interior use and as a filler in rubber goods, paper, linoleum, oilcloth, etc. The report discusses in detail production and sales, market and prices, and imports and exports. In 1918, 62,400 T. of lithopone were sold, in 1928 this had increased to 200,469 short T. The report also gives statistics and methods of preparation of blanc fixe, barium carbonate, chloride, nitrate, hydroxide, and dioxide. For Part I see *Ceram. Abs.*, **9** [5], 376 (1930). R.A.H.

Geophysical abstracts. XIII. F. W. Lee. Bur. Mines, *Information Circ.*, No. 6309, 26 pp. (May, 1930).—In continuation of previous circulars a series of abstracts are given which were taken from the world's literature of geophysical prospecting. For Part XII see *Ceram. Abs.*, **9** [7], 575 (1930). R.A.H.

Natural Resources of Quebec. Canadian Dept. of Interior, Ottawa. *Clay Prod. News*, **3** [6], 8–9 (1930).—A review of the references made to clay products. W.C.O.W.

Geology and Economic Deposits of the Moose River Basin. W. S. Dyer. Ontario Dept. of Mines Pub.; *Rock Prod.*, **33** [13], 110 (1930).—The largest deposit of gypsum in Canada is in Moose River Basin. The mineral is white and of very good quality. The paper contains also a report of the carbonaceous and clay deposits giving data on some of the clays of the region. W.W.M.

Report on Fluorspar. M. E. Wilson. *Geological Surv.*; *Clay Prod. News*, **3** [6], 13 (1930).—A report on the fluorspar deposits of Canada is given. A discussion of the general character and origin of fluorspar deposits is given in one chapter. The mining of fluorite in Canada is largely governed by domestic requirements, as shipments into the U.S. are affected by an adverse tariff of $7.50 per T. W.C.O.W.

Chemistry and Physics

Cristobalite liquidus in alkali oxide–silica systems and heat of fusion of cristobalite. F. C. Kracek. *Jour. Amer. Chem. Soc.*, **52** [4], 1436–42 (1930).—K. determined the melting point curves of cristobalite in silica-rich mixtures of Li_2O, Na_2O, K_2O, Rb_2O, and Cs_2O with SiO_2 and discusses the characteristics of these curves. The heat of fusion of cristobalite was calculated as 30.5 cal./g. from the melting point lowering of cristobalite by Rb_2O and Cs_2O. R.G.M.

Studies on thermochemistry of compounds occurring in the system CaO–Al_2O_3–SiO_2. III. Heat of hydration of calcium oxide. T. Thorvaldson, W. G. Brown, and C. R. Peaker. *Jour. Amer. Chem. Soc.*, **52** [3], 910–15 (1930).—The value 276.3 cal. 20° per g. or 15.49 kg. cal. 20° (64.76 kg.) per mole was obtained for the heat of hydration of CaO in saturated lime water at 20°. Microscopic examination indicated that physical changes in the hydrated material continue for a long time after the temperature of the calorimeter comes to apparent constancy. It is suggested that changes in the energy of surface and of crystal lattice may be responsible for the discrepancy between the observed and calculated results for the heat of hydration of calcium oxide. For Part II see *Ceram. Abs.*, **9** [7], 580 (1930). R.G.M.

The system potassium metasilicate–silica. F. C. Kracek, N. L. Bowen, and G. W. Morey. *Jour. Phys. Chem.*, **33** [12], 1857–79 (1929).— The mixtures studied were prepared in the form of glasses by decomposing K_2CO_3 with quartz in platinum crucibles. The well-mixed ingredients were sintered at 700 to 800° for several hours to drive off the CO_2. The temperature was then raised gradually so that bubbles could

escape without frothing. The resulting glass was crushed and remelted till the mass was homogeneous. Thermal study was carried out by the quenching method. The length of time required for the initial crystallization and for the attainment of equilibrium in the melt, and the speed with which it was necessary to chill the charge to freeze the equilibrium, varied greatly with the composition. Mixtures whose compositions lie between $K_2O \cdot SiO_2$ and $K_2O \cdot 2SiO_2$ and those containing in excess of 90% SiO_2 crystallize rapidly when the glass is held near the liquidus temperature. Compositions near that of $K_2O \cdot 4SiO_2$ are difficult to crystallize. A temperature-composition diagram is given to 1050°C and 80% SiO_2. The system contains three compounds, $K_2O \cdot SiO_2$, $K_2O \cdot 2SiO_2$ and $K_2O \cdot 4SiO_2$ whose melting points are 976°, 1036°, and 765°, respectively. The respective eutectics between these compounds are 775° and 45.4 weight % SiO_2, and 752° and 69.0 weight % SiO_2. The eutectic between $K_2O \cdot 4SiO_2$ and high quartz is at 764° and 72.0% SiO_2, very near the $K_2O \cdot 4SiO_2$ composition. $K_2O \cdot 2SiO_2$ presents an unusual type of liquidus curve and enters into solid solution with excess of both K_2O and SiO_2, the solid solutions decomposing into the pure compound and a melt at 814° and 993°. On the two sides of the composition of the compound a reversible inversion is found in $K_2O \cdot 2SiO_2$ at 590°. Lithium enters into the formation of orthosilicate, metasilicate, and disilicate, only the metasilicate $Li_2O \cdot SiO_2$, apparently having a congruent melting point. Sodium forms the congruent melting $Na_2O \cdot SiO_2$ and $Na_2O \cdot 2SiO_2$; nothing is known about the orthosilicate, $Na_4 \cdot SiO_4$. Potassium exhibits, in addition to the congruently melting $K_2O \cdot SiO_2$ and $K_2O \cdot 2SiO_2$ another compound, $K_2O \cdot 4SiO_2$. Many references have been in the literature to compounds on the general formula $2Me_2O \cdot 5SiO_2$ supposed to be formed by the alkalis. It is significant that in no case investigated with competent methods have such compounds been found at the liquidus. G.R.S.

Hydrated polycalcium aluminates. A. TRAVERS AND J. SCHNOUTKA. *Compt. rend.*, **188,** 1677–79 (1929).—The precipitate formed when solutions of $Ca(NO_3)_2$ and K aluminate are allowed to react vary in composition as well as in crystalline form with increasing alkalinity of the solution. At p_H 11.62 to 11.79 there are produced spherical groups of crystals, $Al_2O_3 \cdot 3.75CaO$; at p_H 11.79 to 11.89, hexagonal crystals; above p_H 11.89 hexagonal crystals and rhombohedra of $Ca(OH)_2$. All contain more CaO than the tricalcium aluminate, $3CaO \cdot Al_2O_3 \cdot 21H_2O$(I), despite similarity in crystalline form. These various precipitates are believed to be solid solutions of varying amounts of CaO in I. The free CaO is much more rapidly dissolved from the dehydrated powdered substance by 6*N* HCl than I; hence after repeated treatment the residue is I. T. and S. question the existence of bicalcium aluminate hydrate described by Allen and Rogers. See following abstract. (*C.A.*)

Study of the aluminates of calcium hydrates. A. TRAVERS AND J. SCHNOUTKA. *Ann. chim.*, **13** [10], 253–335 (1930).—The paper discusses in detail (1) the preparation, constitution, and properties of K aluminate, (2) the aluminates of Ca hydrates, (3) complex combinations of aluminates of Ca hydrate with chloride and sulphate of Ca. K aluminate is formed by a solution of potash acting on Al. To prevent hydrolysis 5% K in excess of the theoretical quantity must be added. Saturated water solutions undergo almost complete hydrolysis, producing crystallized $Al(OH)_3$ which shows remarkable resistance to acids and bases, being unchanged by 0.1 *N* HCl. A gel of $Al(OH)_3$ freshly prepared by the action of a base on a salt of Al dissolves the quantity of lime corresponding to monocalcium aluminate. Solutions of this salt are obtained by dissolving anhydrous $Al_2O_3 \cdot CaO$ in water, but it is impossible to crystallize the aluminate of monocalcium hydrate from these. By adding lime water to a solution of monocalcium aluminate, many polycalcium aluminates are precipitated which are much less soluble than the first. Their formation is determined by the p_H value of the solu-

tion. Their formation, composition, and properties are discussed. By removing water all these crystallized aluminates decompose into monocalcium aluminate and lime, the mechanism of their solution being the inverse of that of their formation. Results of treatment by various reagents are given. Definite compounds were not formed by solutions of various chlorides, but a combination of the aluminate and the sulphate of Ca corresponded exactly to the formula $Al_2O_3 \cdot 3CaO \cdot 2.5CaSO_4 \cdot 3H_2O$, crystallized in long needles like those of tricalcium aluminate. From the ease of formation of these Ca aluminates and their solutions in sulphates, their existence in cement is probable, and their stability in saturated solution of $MgSO_4$ and relatively feeble attack by saturated solution of $CaSO_4$ explains their value in the resistance of cement to Mg and sulphate waters. Tables showing results leading to these conclusions are given, and micrographic plates showing the crystalline forms described. Bibliographies are given. (*C.A.*)

Barium aluminates. E. MARTIN. *Chem. and Ind.*, **47**, 564–72 (1929); *Sprechsaal*, **63** [22], 409 (1930).—When solutions of alkali aluminates stand for some time they precipitate an alumina hydrate which gives the composition $Al_2O_3 \cdot 3H_2O$ on heating up to 160°C; with a further increase of temperature, water is given off and the composition $Al_2O_3 \cdot 2H_2O$ is present at about 225°; between 225° and 235° the hydrate loses another molecule of water, forming $Al_2O_3 \cdot H_2O$ and the remaining water is slowly and continuously given off up to a temperature of above 1000°. M. considers that the true valences have only a secondary significance in such compositions, and that the molecules always have a greater tendency to aggregate with rising temperature and an increased loss of water. This alumina hydrate was fused with varying quantities of barium carbonate and a succession of aluminates of barium of the composition $nAl_2O_3(n + 1)BaO$ was ascertained; *e.g.*, well-crystallized $10Al_2O_3 \cdot 11BaO$. The barium aluminate solutions disintegrate forming simpler aluminates which are partly insoluble, amorphously precipitated: those containing the least BaO partly crystallize, and those richest in barium remain partly dissolved. In the calcium aluminates the proportions are quite similar. A tribarium aluminate $(Al_2O_3 \cdot 3BaO)n$ was produced at a temperature of a flaming arc; the question concerned the preparation of compounds richest in barium. The solutions of this composition are much more stable than the other aluminates prepared at lower temperatures. M. sees in this easily prepared composition an appropriate agent for purifying water. The aluminates of calcium are briefly treated and are of technical importance to the cement industry. The total alumina content of Portland cements combines in the form of silica aluminates and the Ca as aluminate is not found as frequently as would be supposed. The destructive action of water containing sulphates on Portland cement buildings is accounted for by the fact that silico-aluminates containing sulphuric acid are formed. M.V.K.

Determination of titanium and iron in silicates. C. V. POTAPENKO. *Ceramics and Glass*, **6** [1], 29–31 (1930).—P. describes a method for the determination of iron and titanium in silicates. The results obtained were as follows: (1) The fusions of silicates with $KNaCO_3$ or Na_2CO_3 can be brought into solution without the separation of silicic acid. (2) The silicic acid which is found in the solutions has no effect on the results of the determination of iron and titanium by volumetric or colorimetric methods. (3) The low results for titanium can be explained by the formation of meta-titanic acid (during the fusion of melts) which does not oxidize into pertitanic acid. This phenomenon is avoided by heating the solutions to boiling temperature for 10 or 15 minutes. (4) The influence of alkali sulphates during a colorimetric determination of iron is so great that it is necessary to add equivalent quantities of alkalis to the standard solution. (5) Aluminum combined with sulphuric acid lowers the results for iron, but with 10% sulphuric acid this lowering does not exceed 2%, if the Al_2O_3 content

in the silicic acid is not greater than 50%. Aluminum combined with sulphuric acid does not visibly lower the results of the determination of titanium in the presence of concentration of H_2SO_4 of 5% or 10%. M.V.K.

Sodium peroxide-carbon fusion for decomposition of refractories. G. G. MARVIN AND W. C. SCHUMB. *Jour. Amer. Chem. Soc.*, **52** [2], 574–80 (1930).—A quantitative study of the sodium peroxide-carbon method of fusion was made in the case of fifteen highly refractory materials, including both naturally-occurring minerals and artificial products. The results show that, properly executed, this fusion will replace any of the customary methods for the decomposition of refractories, being more complete in many cases, and superior in point of speed and ease of manipulation; being carried out in nickel it obviates the need of platinum crucibles. No loss in weight of the nickel crucible is detected after repeated use. Details are given for the proper method of procedure in preparing the sample and the fusion mixture, as well as the proper proportions of mixture to sample, the mode of charging, firing, and cooling the crucible and the subsequent treatment of the fusion product. It is shown that the unfused residue from a one-gram sample, ground to at least 100-mesh, need not exceed two mg. and that this small residue consists of particles of the original sample and, therefore, may be subtracted from the original weight. R.G.M.

Gravimetric determination of aluminium. A. PICHLER. *Mikrochem. Pregl.-Festschr.*, pp. 6–13 (1929); *Analyst*, **55**, 298 (1930).—Al is determined by weighing as the complex salt with oxyquinoline which contains 5.87% Al. Fe is also precipitated quantitatively if present. H.H.S.

Reaction of alumina. R. RIPAN. *Bull. Univ. Cluj* [Roumania], **3**, 311 (1927); *Giorn. chim. ind. applicata*, **12** [2], 91 (1930).—A new reaction of alumina permits its quantitative determination and separation from other elements. If several drops of a solution of 2% O=C=NK (potassium cyanate) is added to a solution containing an aluminium salt, a hydroxide of aluminium is precipitated, when cold, if the solution is concentrated, and hot if dilute. When heated the hydroxide of alumina congeals, becomes granular, and settles easily. As the precipitation is quantitative this method holds good, even with excess NH_4Cl present, not only for the quantitative determination of alumina but also for separating it from zinc and manganese which do not precipitate with O=C=NK in the presence of NH_4Cl. Error 0.02%. M.V.K.

New gravimetric methods for the quantitative separation of aluminum and phosphate ions from manganous, ferrous, calcium, and magnesium ions. BOGDAN SOLAJA. *Z. anal. Chem.*, **80** [9–10], 334–51 (1930). W.C.O.W.

Quantitative determination of manganese, iron, and aluminum in the presence of phosphoric acid. J. S. TELETOV AND N. N. ANDRONNIKOVA. *Z. anal. Chem.*, **80** [9–10], 351–57 (1930); for abstract see *Ceram. Abs.*, **8** [12], 923 (1929). W.C.O.W.

New method for separation of aluminum-iron group. T. L. YU. *Science* [China], **14**, 810–20 (1930).—Time-saving variations in the method of A. A. Noves are suggested. NiS, CoS, and $Al(OH)_3$ remain insoluble on the addition of 4 *N* HCl to the NH_4OH and $(NH_4)_2S$ precipitate. Al is detected with alizarin. For Co and Ni, α-nitro-β-naphthol and dimethylglyoxime are used. (*C.A.*)

Vanadium compounds as catalysts for the oxidation of sulphur dioxide. H. N. HOLMES AND A. L. ELDER. *Ind. Eng. Chem.*, **22** [5], 471–73 (1930).—A new method for preparing extremely intimate mixtures of catalysts containing vanadium compounds, promotors, and supports is described in detail. The best of these shows a 98% conversion of sulphur dioxide to sulphur trioxide without any decrease in efficiency even after 60 hrs. of continuous use. Intimate mixtures of vanadates with silicates, hydrated silica, and promotors such as compounds of iron, calcium, copper, cobalt, and nickel were made and tested. R.G.M.

Volumetric estimation of sodium. E. R. COLEY. *Jour. Amer. Chem. Soc.*, **52** [4], 1349–53 (1930).—A rapid volumetric method for the determination of sodium based upon its precipitation as sodium magnesium uranyl acetate and the titration of the uranium content of the precipitate by means of a standard phosphate solution is described. R.G.M.

Determination of calcium by ignition of calcium oxalate to carbonate in air. H. H. WILLARD AND A. W. BOLDYREFF. *Jour. Amer. Chem. Soc.*, **52** [5], 1888–92 (1930).—Ignition of calcium oxalate in air was studied at 350, 400, 450, 500, 550, and 600°C. Between 450°C and 500°C the oxalate is quantitatively converted into carbonate in one or two hrs. This is made the basis of an accurate method for the gravimetric determination of calcium. A simple method is described for adjusting a furnace to a desired temperature by utilizing the melting points of suitable salts. R.G.M.

Volumetric method for determination of barium and sulphate ions. R. STREBINGER AND L. V. ZOMBORY. *Z. anal. Chem.*, **1–2**, 1–8 (1929); *Sprechsaal*, **63** [22], 409 (1930).—Barium salt solutions with about 1% of watery solution of sodium rhodinate give a fine flaky, carmine red sediment; the sediment deposits slowly and gives an intensely red color to the liquid. The reagent solution must be used fresh. When dilute sulphuric acid is added to the barium rhodinate in the presence of hydrogen ions, the carmine-red solution becomes colorless. By adding alkali sulphate to a neutral solution, a sudden change from carmine red to yellow takes place (with the formation of yellow alkali rhodinate). The barium ions are determined by adding to the solution, 10 to 15 mg. of sodium rhodinate in 5 cc. water, and then titrating with a known sulphate solution (ammonia alkali sulphate or free sulphuric acid; in the first case a small addition of alcohol to the barium solution is advantageous) until a sudden change of color from carmine red to yellow takes place; or, in case of titration with a pure acid, until the disappearance of the red color. The same principle is used for determination of sulphate ions; sulphate ions are precipitated with a known surplus quantity of Ba ions and the surplus is titrated back as indicated. M.V.K.

Determining manganese. ROY P. HUDSON. *Blast Fur. Steel Plant*, **18** [7], 1152–53 (1930).—Manganese is always present in iron and steel, occurring as the sulphide, carbide, and in solid solution in the iron. Gravimetric methods of determining manganese are seldom employed in routine iron and steel analysis, due to their length and complicated manipulation. Their use is generally confined to the preparation of standards and to umpire analysis. The method generally used in these cases is the basic acetate process or one of its modifications. The chlorate process may also be used. A modification of this process, called the Ford-Williams method, is a volumetric method. Details of it and Volhard's process, Crobaugh's modification, the bismuthate process, the bismuthate-arsenite method, and the persulphate-arsenite method are given. E.J.V.

Ceric sulphate as volumetric oxidizing agent. XII. Determination of tellerous acid. H. H. WILLARD AND P. YOUNG. *Jour. Amer. Chem. Soc.*, **52** [2], 553–56 (1930).—**XIII. Determination of mercurous mercury.** *Ibid.*, **52** [2], 557–59 (1930).—For Part XI see *Ceram. Abs.*, **9** [7], 577 (1930). R.G.M.

Applications of ceric sulphate in volumetric analysis. VII. Oxidation of hydroquinone by ceric sulphate. N. H. FURMAN AND J. H. WALLACE, JR. *Jour. Amer. Chem. Soc.*, **52** [4], 1443–47 (1930).—The reaction between 0.1 *N* solutions of hydroquinone and ceric sulphate are shown to be stoichiometric, rapid, and convenient. For Parts I to VI see *Ceram. Abs.*, **8** [12], 924 (1929). R.G.M.

Detection and estimation of cobalt in presence of nickel. A. LIEBERSON. *Jour. Amer. Chem. Soc.*, **52** [2], 464–65 (1930). R.G.M.

Determination of boric oxide in glass. VIOLET DIMBLEBY. *Jour. Soc. Glass Tech.*,

14 [53], 51–63 (1930).—The determination of boric oxide in silicates may be divided into two classes, (1) removal of silica and bases which interfere with boric oxide, and (2) separation of the oxide as methyl borate from the other constituents of the silicate by a distillation method. Because of difficulties reported by other workers engaged in the analysis of glasses containing boric oxide, a number of tests were undertaken. Investigation of the round-bottom flasks used for the boiling periods showed that the previous history and age of the flasks affect their behavior during the boiling process. Good quality resistance flasks were far less susceptible to attack by the solutions used than the glass free from boric oxide. The amount of boric oxide or alkali extracted during a blank run was very small. Blank runs of flasks must be made frequently. Tests on the decomposition of solid calcium carbonate when boiled in water showed that the greater the amount of calcium carbonate present and also the longer the time of boiling, the greater was the alkalinity of the solutions. The precipitate obtained with calcium carbonate should be treated with dilute acid and a reprecipitation made to avoid serious loss of boric oxide by retention in the precipitate, especially when the B_2O_3 content of the glass is 5% or more. The amount of phenolphthalein used in titrations should be less than 0.3 cc. of a 1 or 2% solution of the indicator. When the amount of $CaCO_3$ used in excess, and the time of the last boiling period were carefully controlled, very good agreement was obtained by different workers. Increase in $CaCO_3$ and in duration of boiling gave low results. A procedure is recommended for the determination of boric oxide in (1) simple soda-lime-boric oxide-silica glasses, and (2) in glasses rich in boric oxide and glasses containing lead or zinc. G.R.S.

Method for silica determination in lead glasses. S. R. SCHOLES. *Glass Ind.*, **11** [7], 164 (1930).—For silica estimation in lead glasses, the glass is ground in an agate mortar to pass a 100-mesh sieve, and a mixture of 0.5 g. of glass, 0.5 g. NaOH, and about 3 g. $NaNO_3$ is fused in a platinum crucible. The heat must be closely controlled to avoid the carrying away of undecomposed particles against the lid in the effervescence of the mixture. The reaction is complete in about 1 hour at 300°C. After cooling, the melt is dissolved from the crucible by means of hot water. At this stage the lead oxide is present as a yellow suspension. If the digestion with hot water has been complete, the solution in acid is practically clear. After evaporation on a water-bath to dryness, the residue is covered with dilute (1:1) HCl, and evaporates again before taking up in acidified water for filtration. The purpose of the second evaporation is to convert nitrates to chlorides more completely. The silica must be well washed with hot water because of the limited solubility of lead chloride. The usual evaporation of the filtrate and drying of the residue at 120°C is recommended. E.J.V.

Micro-determination of magnesium with o-oxyquinoline. R. STREBINGER AND W. REIF. *Mikrochem. Pregl-Festschr.*, 319–23 (1929); *Analyst*, **55**, 297–98 (1930).—The ammoniacal Mg solution is heated to 70°C, and the Mg is precipitated with 1% alcoholic solution of oxyquinoline. The precipitate is filtered and weighed according to the Pregl method and contains 6.98% Mg. H.H.S.

New phenomena in X-ray scattering. J. A. GRAY AND W. H. ZINN. *Can. Jour. Research*, **2** [4], 291 (1930).—X-rays were scattered by a number of samples of graphite and charcoal in such a manner that the scattering increased the intensity as the scattering angle approached zero. In certain cases the scattering at small angles was very similar to the scattering of alpha particles; this result cannot be explained easily on the basis of the current views on the nature of X-rays and matter. Experiments are being devised to test what part adsorbed gases play in the phenomena, and to determine whether the scattering at very small angles is a true particle scattering. W.L.

Micro-analysis. ANON. *Sci. Supp.*, **71** [1830], 10 (1930).—Methods of analysis of particles so small that hitherto they defied all attempts to determine their compo-

sition are explained by W. C. MacTavish. The composition of a fraction of a drop of liquid can be determined by the "microvaporimetric molecular weight method of analysis." A description is given of a device, the automatic chemist, that uses an electric eye to keep the analysis under control. G.R.S.

Photoelectric and thermionic properties of platinum-coated glass filaments. A. KEITH BREWER. *Phys. Rev.*, **35** [11], 1360–66 (1930).—The photoelectric and thermionic properties of platinum sputtered glass filaments are discussed, special attention being given to the effect of temperature and to the electrolysis of potassium through the glass to or from the sputtered coating. When electrolysis is away from the surface, the photoelectric threshold is independent of the temperature up to 450° and is close to 2720A. With electrolysis toward the surface the threshold remains at 2720A up to 260°C above which it shifts toward the red with rising temperature, reaching a maximum value of about 4300A at 410°C. Electrolysis produces identical effects on the photoelectric and thermionic emissivity for electrons; the effect on positive ion emission is similar also except that a peculiar maximum in the emissivity occurs for a specific electrolysis potential. Ultra-violet radiation has no effect on the thermionic emission of electrons or positive ions from this type of filament. D.E.S.

Quantitative chemical analysis by means of X-ray emission spectra. H. SCHEIBER. *Z. Physik*, **58** [10], 619–50 (1929).—A new fluorescence method is described for the quantitative determination of substances. The method is not affected by the presence of foreign materials as is the usual emission method. Its application in the analysis of rare earth oxides, platinum metals, etc., is discussed as well as the sources of error which may be expected. The maximum error in the concentration determination of an element is 7%. L.T.B.

Rapid method for determination of moisture in fireclay, semiporcelain, and granulated blast-furnace slag. PETER P. BUDNIKOFF. *Chem.-Ztg.*, **54**, 202–203 (1930).—A 20-g. sample contained in a weighed glass is placed in a drying oven (air bath) maintained at 110°; a current of air, purified by passage through soda lime and H_2SO_4, is drawn through the apparatus by a filter pump. Higher moisture determinations are obtained than by the ordinary method. (*C.A.*)

Effects of oxides on a raw lead glaze. H. N. BOSE. *Jour. Indian Ceram. Soc.*, **2**, 7 (1930).—Influences of different metallic and nonmetallic oxides on a raw majolica glaze is investigated and results tabulated. A.A.

Adsorption and emulsion formation. P. G. NUTTING. *Science*, **71** [1828], 36–37 (1930).—Oil and water shaken together form an emulsion. If oil and mud are shaken together an emulsion is formed which does not disintegrate on standing but resists heating and chemical reagents to a remarkable degree. The oil may be crude, refined, heavy oil, gasoline, or ether, while the mud may be sand, clay, road dust, metal powder, or fibrous dust mixed with water. Gasoline and clay make a convenient pair to experiment with. A discussion is given of the clearing of a clay suspension in water by shaking with gasoline, and formation at the interface between the two liquids of a thin skin containing the solid particles. The solid particles cannot spread like a liquid at an interface, and being insoluble, can only adsorb the two liquids and mesh together. The theory underlying the formation of this clay-water-gasoline emulsion is discussed. G.R.S.

Apparent specific gravity and moisture content of clay. FRANK K. CAMERON AND RICHARD A. LINEBERRY. *Colloid Symposium Annual*, **7**, 179–89 (1929).—On adding water to clays ground to 100-mesh no material change in apparent specific gravity occurred below 2.5% moisture, above which "balling" began to cease and the specific gravity to rise. Analogous phenomena occur with $BaSO_4$, but with less water before the change, and with pumice with more water. With solutions of NaCl and $CaCl_2$

instead of water, similar results for clay appeared, but on substituting organic liquids which do not readily wet clay (isopropyl alcohol, C_6H_6, $(CH_3)_2CO$, $(C_2H_5)_2O$), the curves resembled those obtained from pumice and water. Grinding increased the apparent specific gravity. Plasticity in a poly-component system is due mainly to a high surface tension, and, as the surface tension is correlated to apparent specific gravity, the latter, being easily determined, may be used in ceramic plant control. (*C.A.*)

Investigations of clay suspensions. RENÉ DUBRISSAY, J. J. TRILLAT, AND ASTIER. *Rev. gén. colloides*, pp. 1–9 (January, 1930); *Tonind.-Ztg.*, **54** [48], 802 (1930); for abstract see *Ceram. Abs.*, **9** [6], 471 (1930). M.V.K.

Velocity of the slip and grain size. A. H. M. ANDREASEN AND J. J. v. LUNDBERG. *Kolloid. Z.*, **49** [1], 48–51 (1929); *Sprechsaal*, **63** [26], 487 (1930).—The authors investigated the relation between the grain size and velocity of the slip in a Shöne slip funnel. The slip apparatus and process are described. The determination of the grain size was made by calculating and weighing small fractions. As a result of investigations, the authors found that Stoke's law has approximate validity within the limits of the grain sizes investigated (12.4 to 87.9 kμ), and that with greater velocity of the slip, there is a slight tendency toward a relatively greater increase of the corresponding grain size, which is in conformity with the hydrodynamic theory. M.V.K.

Purification of tannery effluents by clay colloids. J. BESSE. *Le Cuir Tech.*, **18**, 244–46, 294–97 (1929); *Jour. Amer. Leather Chemists Assn.*, **25**, 158 (1930).—A colloidal solution of brick clay containing 20 g. of clay and 0.5 g. Na_2CO_3 per liter can be used to flocculate and remove the impurities from tannery effluents, the volume of clay suspension being 1 to 4 times the volume of the effluent. H.H.S.

Bentonite and aquagel. H. LUFTSCHITZ. *Rev. mat. constr. trav. pub.*, No. 247, pp. 148–50 (1930).—Graphs show the relative viscosities and relative plasticities of hydrated lime, bentonite, and aquagel. A.J.M.

Separation of colloidal material from certain Ohio shales. ANON. Bur. Stand., *Tech. News Bull.*, No. 158, p. 57 (May, 1930).—The separation of the colloidal material from certain Ohio shales has been completed at the Columbus branch of the Bureau. The method used consisted of blunging, sedimentation, supercentrifuging at speeds of 12,000 and 20,000 r.p.m., and filtering through Pasteur tubes. The material separated at 12,000 r.p.m. varies from 0.2% for the Chagrin shale to 11.4% for the Bedford; the material separated at 20,000 r.p.m. ranged from 0% for the former to 2.6% for the latter. The quantities obtained for the other 8 studied were intermediate between these two. In general, the physical properties increase with increase of colloidal matter found. R.A.H.

Contribution to study of drying of clays and clay bodies. V. BODIN AND P. GAILLARD. *Rev. mat. constr. trav. pub.*, No. 248, pp. 83–87B (1930); for abstract see *Ceram. Abs.*, **9** [8], 678 (1930). A.J.M.

Chart for finding solids in a mixture. ANON. *Rock Prod.*, **33** [14], 81 (1930).—A chart is given from which the percentage of solids in a mixture can be read if the specific gravities of the solids and the mixture are known and the liquid of the mixture is water. W.W.M.

Studies in heat transmission. I. Measurement of fluid and surface temperatures. II. Dehumidification. III. Flow of fluids at low velocities. A. P. COLBURN AND O. A. HOUGEN. *Ind. Eng. Chem.*, **22** [5], 522–39 (1930).—The accuracy of experimental data on heat transmission depends on exact measurements of temperatures of surfaces and fluid streams. The serious errors introduced by the improper use of thermocouples are demonstrated. A review and criticism of previous methods are given. Empirical and theoretical equations are developed for both mass- and heat-

transmission coefficients of condensing steam-gas films in terms of all operating variables. Curves and charts are included. R.G.M.

Determining specific gravity of cement. KARL E. DORSCH. *Tonind.-Ztg.*, **54** [37], 627–28 (1930).—There are two methods of determining specific gravity of cement: (1) scientific method which gives very exact values, and (2) technical method which is quicker but less exact. D. describes the apparatus used in both methods and gives a table of the specific gravity of different cements. M.V.K.

Effect of time and temperature on dielectric losses. H. W. L. BRÜCKMAN. *Electrotech. Z.*, **50** [12], 1873–75 (1929).—A description is given which can be used to measure the dielectric losses of various materials at a given pressure up to 20 atmospheres, temperature up to 120°C, and voltages up to 60 kv. Mention is made of several experiments, carried out with this apparatus, on rubber and oil samples, air and oxygen being excluded. A theoretical explanation is given of the results obtained, and a discussion of the interpretation of the mechanism of high-tension cable breakdowns in terms of the properties of insulating oils under changing electrical and physical conditions. M.A.B.

Standard materials for expansion measurements on solid bodies up to 1400°. WILLI M. COHN. *Ann. Physik*, **5** [4], 493–512 (1930).—The present standards used in the comparison method for measuring expansion are discussed. The possibilities of fused silica, ZrO_2, stoneware, and Marquardt porcelain as standard materials are investigated. Conclusion: Fused silica and ZrO_2 are good to 1000°, the stoneware to 1200°, and the porcelain to 1400°. (*C.A.*)

Commercial standard classifications for feldspar recently adopted. ANON. *Rock Prod.*, **33** [13], 79–81 (1930); see *Ceram. Abs.*, **9** [6], 471 (1930). W.W.M.

BOOKS, BOOKLETS, AND BULLETINS

Select Methods of Metallurgical Analysis. WILLIAM A. NAISH AND JOHN E. CLENNELL. John Wiley & Sons, N. Y. $7.50. Reviewed in *Mining and Met.*, **11** [282], 24 (1930); for abstract see *Ceram. Abs.*, **9** [7], 585 (1930). E.J.V.

Electrodeposition of uncommon metals. ANON. *Nat. Glass Budget*, **46** [1], 14 (1930).—The widespread use of chromium-plated materials has demonstrated the value of research in the electrodeposition of uncommon metals. It was with this idea in mind that the investigation reported in Bulletin No. 206 of the Engineering Experiment Station of the Univ. of Ill. was undertaken. On account of the industrial interest in them it was decided to study aluminium, beryllium, boron, chromium, tungsten, titanium, vanadium, and cerium. The bulletin contains a short history of the electrodeposition of these metals, the theory of electroplating them, the experimental work involved, and the results obtained from the investigation. E.P.R.

Effects of Moisture on Chemical and Physical Changes. J. W. SMITH. Longmans, Green & Co., N. Y. 235 pp., illus., diagrs., tables, $5.00. Reviewed in *Mining and Met.*, **11** [282], 22 (1930).—It has long been known that small quantities of water exercise a most important catalytic effect on the velocity of many chemical reactions and in recent years attention has been called to remarkable phenomena that appear when solids and liquids are dried intensively. Minute traces of moisture influence the physical properties. The available data on the effects of removing water vapor from chemical systems are collected in the present work and correlated. Students of physics and physical chemistry will find it a useful summary of a curious and puzzling group of phenomena. E.J.V.

Notes on Hydrogen Ion Measurements. Notebook No. 3 (1930). LEEDS AND NORTHRUP CO.—This is a concise treatise in 48 papers with chapters on the following topics: (1) Meaning of Hydrogen Ion Concentration and p_H Value; (2) Electrometric

Hydrogen Ion Measurements; (3) Hydrogen Electrode; (4) Calomel Electrode; (5) Potentiometer Principle, (6) Assembly for Hydrogen Ion Measurement; and (7) Quinhydrone p_H Indicator. The booklet is easily read, well illustrated, and in good balance. Copies may be had without charge.

Notes on the Analysis of Glasses, Refractory Materials, and Silicate Slags. Edited by W. E. S. TURNER. Society of Glass Technology, Sheffield, England. 96 pp. This book consists of a series of papers read at meetings of the Society of Glass Technology, and are reprinted from the *Journal of the Society of Glass Technology*. The papers include "A Critical Survey of the Methods in Use for the Analysis of the Simpler Glasses," by W. H. Withey (see *Ceram. Abs.*, **6** [10], 427 (1927)); "Notes on Some Methods Used in the Analysis of Glasses," by Violet Dimbleby (see *Ceram. Abs.*, **6** [10], 430 (1927)); "Notes on the Analysis of Refractories," by W. J. Rees (see *Ceram. Abs.*, **6** [10], 445 (1927)); "The Analysis of Silicate Slags," by T. P. Colclough (see *Ceram. Abs.*, **6** [10], 458 (1927)); "The Analysis of Opal and Alabaster Glasses," by J. D. Cauwood, J. H. Davidson, and Violet Dimbleby (see *Ceram. Abs.*, **8** [1], 22 (1929)); "The Analysis of Opal Glasses," by W. Singleton and R. C. Chirnside (see *Ceram. Abs.*, **7** [7], 443 (1928)); "The Analysis of Soda-Lime-Silica Glass," by G. E. F. Lundell and H. B. Knowles (see *Ceram. Abs.*, **6** [12], 615 (1927)); and "The Determination of Sulphur as Sulphide in Glasses," by H. Heinrichs (see *Ceram. Abs.*, **7** [4], 260 (1928)). For abstract see *Ceram. Abs.*, **9** [7], 521 (1930). E.J.V.

Electron Physics. J. B. HOAG. Chapman & Hall, London. *Elec. Rev.*, **106** [2739], 981 (1930); for abstract see *Ceram. Abs.*, **9** [3], 234 (1930). E.P.R.

Annual Reports of the Progress of Applied Chemistry for 1929. SOCIETY OF CHEMICAL INDUSTRY. Vol. 14, London. 754 pp.—A review of the accomplishments for the year is given in 24 different branches of applied chemistry with valuable references to the original literature. Chapters of interest to ceramists include Fuel, by J. G. King, pp. 30–60; Glass, by H. W. Howes, pp. 235–44; Refractories, Ceramics, and Cements, by Walter C. Hancock, pp. 245–62. W.C.O.W.

Quantitative Analysis of Inorganic Materials. N. HACKNEY. Chas. Griffin & Co., Ltd., London, 1930. Price 30s. H.H.S.

Publications of the Kaiser Wilhelm-Institute for Silicate Studies. (Veröffentlichungen aus dem Kaiser Wilhelm-Institut für Silicatforschung.) W. EITEL. Volume I. Published by Gebruder Börnträger, Berlin. 28 M. *Naturwissenschaften*, **18** [19], 422 (1930).—This volume contains the Institutes publications for the years 1926 and 1927. L.T.B.

Calorimetric researches on dehydrated kaolin. E. KLEVER AND E. KORDES. *Repts. Kaiser Wilhelm Inst. Silicate Researches*, Berlin-Dahlem, **3**, 6 pp. (1930).—The reactions of Zettlitz kaolin when heated were investigated by determining the heat of solution of the samples. Between 550°C and 900°C, a compound (metakaolin by F. Rinne) exists and its heat of formation from the oxides amounts to -15.8 ± 2.5 cal./mol. The samples fired between 900° and 1000° show a heat of solution which corresponds to the sum of heats of solution of the free oxides. It can be concluded from the exothermic reaction at this temperature that "metakaolin probably disintegrates into the free oxides." Between 1170°C and 1220°C, a second exothermic effect was determined from the heating curves, which is interpreted to indicate the formation of sillimanite in high-fired kaolin. M.V.K.

A German-English Technical and Scientific Dictionary. A. WEBEL. 887 pp. George Routledge and Sons, Ltd., London. Price 36s. Reviewed in *Colliery Guardian*, **140** [3622], 2076 (1930). E.J.V.

PATENTS

Dissolving silicate of soda. LLOYD B. EDGERTON. U. S. 1,763,845, June 17, 1930.

A silicate dissolver comprising in combination, a tank, a silicate supporting screen near the bottom of the tank, a standpipe in the tank, openings in the lower portion of the standpipe communicating with the silicate chamber above the screen, and means for introducing a heating medium into the bottom of the standpipe below the openings.

Potassium carbonate. I. G. FARBENINDUSTRIE AKT.-GES. Brit. 327,938, June 12, 1930. Potassium carbonate is freed from alkali chloride by passing ammonia into crude potassium carbonate liquor, preferably to saturation point. Two layers separate, most of the alkali chloride going into the upper one, the lower one giving practically pure potassium carbonate on evaporation.

Silica. A. P. OKATOFF. Brit. 328,241, June 18, 1930. Silica gel is prepared by adding sodium silicate solution to hydrochloric acid in such quantity that the mixture remains acid. The mixture is allowed to stand until the jelly first formed becomes covered with liquid and commences to break up. The jelly is then broken to pieces and treated with a solution of an alkali or ammonium salt of sulphuric, phosphoric, or other dibasic acid containing ammonia in amount insufficient to neutralize all the free acid in the gel. The gel is washed and dried at 150 to 200°C.

Aluminium fluoride. A. CARPMAEL. Brit. 328,688, June 25, 1930. Aluminium fluoride, anhydrous or hydrated, is prepared by treating alumina, or hydrated alumina with gaseous hydrofluoric acid, obtained, for instance, from fluorspar and sulphuric acid. In place of gaseous hydrofluoric acid, a mixture of gaseous hydrofluoric acid and gaseous hydrochloric acid, such as obtained in the process of Brit. 328,211 may be employed, only aluminium fluoride being formed. The amount of water in the product depends on the temperature at which the reaction is carried out, which in any case should not be higher than about 400°C. At 100°C the water content is about 6%, decreasing to practically zero at 200°C and higher. Similar results are obtained when the reaction is carried out at room temperature, and the temperature raised toward the end of the operation.

Borax. THOMAS M. CRAMER. Fr. 677,517, June 27, 1929. Borax is prepared from Na_3BO_3 minerals, such as tincal, by heating the minerals under pressure to above 100° to obtain a solution of the borax in its own water of crystallization, separating the solution from the residues and cooling the solution. An apparatus is described.

(*C.A.*)

General

Will ceramic art education pay? EDITORIAL. *Bull. Amer. Ceram. Soc.*, **9** [7], 211–12 (1930).—Ceramic art education will pay if it trains artists to develop products for specific purposes and to create products for the ever-changing needs. A ceramic art education that is concerned only with form and decoration will not pay unless it develops creative and process control judgment. E.J.V.

Operating results on small heating plant stokers. J. F. BARKLEY. *Fuel Sci. Practice*, **8** [11], 541–43 (1929); for abstract see *Ceram. Abs.*, **8** [10], 774 (1929). R.G.M.

Pulverized fuel in boiler house. G. H. LAKE. *Colliery Guardian*, **140** [3623], 2127–29 (1930).—Certain factors which affect economic steam production are reviewed. If the induced and forced draft fan capacities are sufficiently liberal, the boiler evaporation can be pushed to unexpected rates, particularly with powdered fuel installations. E.J.V.

Heat economy in the clay industry. H. BRAND. *Tonind.-Ztg.*, **54** [38], 637–41 (1930).—Modern heat economy has found a means of minimizing the consumption of coal in boilers and of obtaining uniform economy of heat in a plant by using hot water for transmitting heat. By combining the exhausted steam and heat in a better

way many advantages are obtained, together with an amortization of operating prices. A total utilization of heat of 78.8% was obtained by the plants in operation. M.V.K.

Application of streak and hardness used in clay grading. W. D. KELLER. *Science*, **71** [1838], 220–21 (1930); for abstract see *Ceram. Abs.*, **8** [12], 894 (1929). G.R.S.

Laboratory control of feldspar production and preparation. W. A. SEGER. *Rock Prod.*, **33** [13], 77–78 (1930).—A sampling device at the bin takes samples of the incoming feldspar at given intervals. The average analysis is posted on the bins. Several bins of coarse material having different analyses make it possible to send a uniform product to the fine-grinders. Size analyses are made of the finished product and several standard sizes are kept in storage for the various consumers. W.W.M.

Standardizing cement sieves. E. TAYLOR. *Rock Prod.*, **33** [13], 85 (1930).—T. overcomes error due to wear on fine sieves by keeping a master standardized 200-mesh sieve and comparing the 200-mesh plant sieves with it periodically by sieving the same material several times with each, and averaging the percentage of minus 200-mesh. W.W.M.

Drill for sampling quarry products. REID-KELLETT. *Cement and Cement Mfg.*, July, 1929; *Pit and Quarry*, **19** [2], 116 (1929).—For the comprehensive sampling of pit and quarry products small hand-power diamond drills are recommended. The advantages of the drills are cheapness, accuracy, mobility, and simplicity. For sampling hard crystalline limestone the diamond set bit is necessary. Drilling speed with this bit rarely exceeds 1 ft. per hr. For drilling in chalk or clay, the diamond bit is not required and a core is not obtained, but slurry only. E.P.R.

Preparation of primers for effective rock blasting. PAUL F. LEWIS. *Pit and Quarry*, **18** [13], 78–79 (1929).—Since the direction in which an explosive charge builds up its maximum pressure depends so largely on the position of the detonator in the charge, it follows that the preparation of the priming cartridge is of vital importance. As a detonator exerts its greatest force straight away from its charged end, the first principle of priming is that the long axis of the detonator should be as nearly parallel with the long axis of the cartridge as possible. Various priming procedures are described in detail. E.P.R.

Drilling rock. MINIMAX AKT.-GES. *Pit and Quarry*, **18** [13], 112 (1929).—The dust formed during rock-drilling operations is laid by means of froth which is supplied to a cup placed over the boring and surrounding the drill steel. The froth is produced in a separate chamber in any suitable manner, *e.g.*, by supplying water and compressed air to a vessel containing porous material. E.P.R.

Chemical method of waterproofing and consolidating defective shaft masonry. ANON. *Colliery Guardian*, **140** [3625], 2306 (1930).—A new chemical process of waterproofing and consolidating shaft masonry consists in injecting two chemical solutions into the rock or masonry to be consolidated. The rock, masonry, etc., is first of all impregnated with the first solution containing silicic acid, while the injection of the solution brings about the actual chemical change, the contact of the two chemicals giving a concentration of silicic acid and so consolidating the rock or masonry. Illustrated. E.J.V.

Pulverized fuel. J. T. DUNN AND B. MOORE. *Mech. World*, **87** [2264], 491–93; [2265], 510–11; [2266], 537–39; [2267]; 563–65; [2268]; 575–77 (1930); for abstract see *Ceram. Abs.*, **9** [7], 560 (1930). E.P.R.

Diesel engines, their present and possible applications in pit and quarry industries. II. J. O. DURKEE. *Pit and Quarry*, **19** [2], 89–96 (1929).—The article describes and illustrates the practical applications of oil engines and points to opportunities for saving by the use of this power. For Part I see *Ceram. Abs.*, **9** [7], 553 (1930). E.P.R.

Advantages of testing materials. DRÖGSLER. *Tonind.-Ztg.*, **54** [41], 685–88 (1930).—Examples taken from practical experience illustrate the importance of close coöperation between industry and research in order to obtain uniformly good production at minimum cost. M.V.K.

Scientific method in industry. HENRI LE CHATELIER. *Rev. belge ind. verrières*, **1**, 73–74 (1930). A.J.M.

Mechanization of clay mining. K. A. GOSLICH. *Tonind.-Ztg.*, **54** [37], 621–24 (1930).—G. discusses the mechanization and rationalization of clay mining and indicates the kinds of apparatus to be used. M.V.K.

Founding on clay. ANON. *Engineering*, **129** [3357], 639–40 (1930).—Clay is perhaps the most variable of all materials on which structures may be based. The ability to carry a load without undue settlement may vary from 1 to 7 T. per sq. ft. Work of Prof. Housel of the Univ. of Mich., entitled, "A Practical Method for the Selection of Foundations Based on the Fundamental Research in Soil Mechanics," *Engineering Bull.*, No. 13, is discussed. A.A.

Tensile strength of clay bodies. H. N. BOSE. *Jour. Indian Ceram. Soc.*, **2**, 12 (1930).—For determining the suitable substance which would increase the tensile strength of a clay body in the unfired state, 0.2% of water glass, gelatin, and tannin (finely-powdered Myrabolan) were added separately to a body composed of china clay 50%, quartz 30%, feldspar 20% and allowed to soak overnight. Briquets were cast, dried, and tested for tensile strength. Gelatin gave the greatest strength but the clay was found to stick to the mold and was difficult to remove without breaking. Water glass stood next to gelatin. Tannin was observed to flocculate the liquid and therefore was found unfit for casting slips; it was noted, however, to improve the working quality of the clay body made for throwing or jolleying when aged for a couple of weeks. A.A.

Vibration effects on foundations and masonry structures. ANON. *Eng. News-Rec.*, **104** [22], 900 (1930).—The following conclusions are given: (1) The bearing capacity of masonry walls and piers is not affected appreciably by minor vibrations transmitted through the earth. (2) Where brick masonry is under shear along the joints, the strength is probably impaired by such vibrations. (3) Buildings founded on plastic soil may be expected to settle somewhat when subjected to vibrations caused by heavy street traffic or railroad trains. W.L.

Preservative treatments for stone. ANON. Bur. Stand., *Tech. News Bull.*, No. 150, pp. 94–95 (1929).—Although preservative treatments for stone have been used for a considerable period of time, their value has often been questioned. The article describes and gives the results of tests made on sandstones and limestones, two specimens of each of which were treated with a preservative and two of each were not treated. They were soaked in water and subjected to freezing and thawing cycles until failure. The results showed that the specimens which had received the preservative treatment showed by far the greater resistance to failure in these tests. R.A.H.

Evolution of industrial methods in ten years. GEORGES BLONDEL. *Chaleur ind.* (Special No.), pp. 17–19 (April, 1930). A.J.M.

Insulating fire extinguishers. J. BRANDL. *Electrotech. Z.*, **50** [12], 1806–1807 (1929).—B. gives comparative figures including electrical resistance and price, in addition to the relevant physical and chemical properties, for the following chemical fire extinguishers: methyl bromide, carbon tetrachloride, carbon dioxide, sodium bicarbonate (powder), which may be used upon apparatus at high voltage because of their high insulating value. A brief description is given of an apparatus for testing the effective resistance. M.A.B.

Examination of china clay. R. G. THIN. *Paper Mill*, **52** [52], 20–24 (1929).—

Attention is drawn to the confusion which exists as to the legitimate proportion of moisture and grit in clays and to the necessity of having a method of testing which must be adhered to in every detail. The personal equation in the determination of grit and mica can best be eliminated (or at least reduced to a minimum) by an elutriation test in which the rate of flow can be regulated by passing water under a constant head through a capillary tube of definite bore and length. By means of an apparatus similar to the Schöne elutriator, it was found that with a velocity of 0.3 mm. per sec., particles of sand and mica up to 0.44 mm. in diameter were washed over. See following abstract. (*C.A.*)

Grit in china clay. JAMES STRACHAN. *World's Paper Trade Rev.*, **93**, 482–86 (1930).—The Schöne type of apparatus for the fractionation of clays, etc., is out of date; for rapid work the pipette method and the hydrostatic method are now used, while for more elaborate work the Odén-Keen automatic balance is used, which records a graph of particle-size during sedimentation. There are 2 distinct processes in the physical examination of china clay: (*a*) separation of true grit, (*b*) fractional analysis of the true clay for particle-size. S. considers that a sedimentation method is best suited for both processes and has devised an apparatus (to be described later) which presents the following features: (1) It is possible to work with large samples (5 to 10 g.). (2) The size of the particles is controlled entirely by the time of sedimentation, concentration of suspension, temperature, and p_H value of the water. (3) The water required is reduced to a minimum. (4) The time is reduced to 1 to 1.5 hrs. (5) The separation of the sediment from the suspension occupies a fraction of a second only, dispensing entirely with pouring off or drawing through taps. Grit estimation in clay should be accompanied by a proper mineralogical analysis of the sediment, or at least a differentiation between kaolinite, mica, and quartz sand, which can be done approximately by chemical analysis of the sediment. (*C.A.*)

Metal vs. clay. ANON. *Clay-Worker*, **93** [7], 479 (1930).—A new competition coming into the building world that will have to be met by the clayworking industry is that from the metal industry in the form of fabricated metal for home building. They are designing all-steel homes with a fabricated material produced on a quantity basis and have created concern in lumber circles. E.J.V.

Clayworking from American standpoint. EDWARD ORTON, JR. *Pottery Gaz.*, **55** [637], 1136–38 (1930).—The American viewpoint as to clayworking of thirty years ago and its gradual alteration through the influence of university-trained ceramic engineers is discussed. The conversion of waste products, accomplishments of the new spirit in the field of ceramics, new raw materials, and the value of standards are discussed. This address was delivered at the Clay Convention at Buxton, England, on May 20, 1930. E.J.V.

New V. D. E. rules for heavy current installations below 1000 v. R. ZANDY. *Electrotech. Z.*, **51** [2], 4–7 (1930).—All relevant clauses from the constructional rules are incorporated so that wiremen, erectors, and others shall have all possible guidance in the selection of appropriate material. M.A.B.

Competition in building materials. RALPH P. STODDARD. *Brick Clay Rec.*, **77** [1], 18 (1930).—A glaring weakness in sales promotion which crops out frequently in the clay products industry is that a large portion of the industry has not learned to appreciate where its real competition lies. There is too much competition between face brick, common brick, and hollow tile, where it should be between these three products on the one side and sub-standard units on the other. Lumber and concrete possess a large market that should be obtained by the clay products. E.J.V.

Building Code Committee of the U. S. Department of Commerce. W. K. HATT.

Eng. News-Rec., **104** [23], 926 (1930).—The personnel, operation, and accomplishments of the Building Code Committee are given. W.L.

New tariff laws. ANON. *Brick Clay Rec.*, **77** [1], 20–21 (1930).—The new tariff laws as they affect the ceramic industry, with figures comparing the new tariff schedules with the old and comments from men in the industry are given. E.J.V.

Organization of industrial research. E. R. BENGER. *Ind. Eng. Chem.*, **22** [6], 572–77 (1930).—B. describes the functions of organization in research and states that they comprise the following items: (1) securing the man, (2) providing the money, (3) furnishing the atmosphere, (4) organization to supply accessory service, and (5) capitalization of results. R.G.M.

Trade practice rules submitted to tile industry. ANON. *Brick Clay Rec.*, **76** [12], 776–78 (1930).—At the Trade Practice Conference for the manufacturers, dealers, and distributors of structural clay tile held at St. Louis, Mo., March 31, 1930, two sets of rules were formulated and presented for adoption after due consideration by members of the conference. The rules in the first group are regarded as condemning unfair methods of competition in violation of the law, and are affirmatively approved. Those in group two are accepted as expressions of the trade. The rules are given. E.J.V.

Menace of obsolescence. JULIUS KLEIN. *Clay-Worker*, **93** [7], 486–87 (1930).—A factory cannot derive the full benefits and profits that spring from mechanical efficiency unless it keeps its machinery absolutely up to date, following the progress of invention closely and utilizing the best modern devices that science makes available. This means that the men in charge of a manufacturing enterprise must be willing to get rid of things summarily when they have outlived their usefulness. A piece of equipment or a manufacturing method becomes obsolete only because something better, something more apt and efficient, has been discovered. Some of the cases in which the action of obsolescence has been most drastic are discussed. E.J.V.

Canadian clay imports. ANON. *Clay-Worker*, **93** [7], 487 (1930).—Imports of clay products into Canada during March amounted to $1,107,031, of which $523,068 came from the U.S. and $375,882 from the United Kingdom. Imports of fire brick for the year ending March, 1930, aggregated $2,654,934 as compared with $1,978,074 in the preceding year. China tableware imports were valued at $4,467,393 as against $3,966,869 in the previous year. E.J.V.

Survey of ceramic industry in Ontario. R. J. MONTGOMERY. *Clay Prod. News*, **3** [5], 6–12 (1930).—This progress report indicates in a general way the points being considered in the revised report now being undertaken by the Ontario Department of Mines, and which covers the report prepared by M. B. Baker and published as Vol. 15, Part 2, Ontario Bureau of Mines in 1906. The situation in the brick industry is discussed at length. A movement to consolidate brick plants has begun and will probably grow. The maximum production of common brick was reached in 1913 with a valuation of over three million dollars. The plants in general are not working to capacity and there is over-production. The smaller plants are under considerable handicap where local demand does not take care of their production. Modernization of plants is gradually being effected but too many are being operated with obsolete machinery. Emphasis is placed upon the lack of control apparatus in most plants. The plants of the sewerpipe industry are operated under one head. Drain tile manufacture has shown a satisfactory increase in production the past year, and hollow building tile is a new development since 1906. Pottery production is still low, the electrical porcelain industry is well developed, satisfactory floor tile are being made, and flower pots are produced in large numbers. Paving brick were attempted but are not made, as Ontario clays are unsuitable for this product. Terra cotta is made only

in a small way. The interest in the manufacture of refractories is increasing. The enamel industry is well developed and includes both sheet steel and cast iron. Bottles are the only kind of glassware made, and these are made in a modern up-to-date plant. W.C.O.W.

Developments in fuel economy at Skinningrove. FRANK BAINBRIDGE. *Engineering*, **129** [3355], 588–90; [3356], 617–18 (1930). A.A.

Chemical industry of Czechoslovakia. WILLIAM T. DAUGHERTY. *Commerce Repts.* **27**, 24–25 (1930).—Since October, 1918, when Czechoslovakia became an independent republic, there has been a determined effort to promote industrial development and thus to make the country as self-contained as possible. This development is favored by the rich mineral and other natural resources. Bohemia and Moravia Silesia are particularly fortunate in the possession of high-grade lignite in the former area and coal in both districts. The coal deposits are contiguous with Upper Silesian coal and are especially good for coking. In addition, Czechoslovakia has a self-sufficiency and an export capacity of antimony ores, graphite, quicksilver, kaolin, clays, building stones, magnesite, uranium ore, and feldspar, but shortages in iron ores and pyrites, base and precious metals generally, manganese ores, salt, quartz, and glass sand. E.J.V.

Engineering opportunities in Latin America. ANON. *Sci. Supp.*, **71** [1837], 12 (1930).—R. W. Hebard reports that opportunities similar to those in the U.S. before the Civil War are open to engineers today in Latin America. There are rich productive countries, with an educated, cultured class, but without railways, highways, or ports. Important cities are lacking in adequate water supply or modern sewage and paving. Such a field should attract the American engineer. G.R.S.

Pottery and glassware in Argentina. ANON. *Pottery Gaz.*, **55** [637], 1144–45 (1930).—The production of china and glassware in the Argentine Republic has so far had little effect on the demand for imported goods. Imports of porcelain chinaware from all sources were valued at 825,399 gold pesos in 1928, compared with 783,198 gold pesos in 1927. This trade is mainly controlled by Czechoslovakian and German manufacturers, while France also competes. The importation of glazed tile increased from 9,783,610 kilos in 1927 to 14,046,555 kilos in 1928, of which about 70% was supplied by Germany. There is a fairly important local production of glassware, but the output from domestic concerns is chiefly confined to the cheaper classes of undecorated tableware. British table and fancy glassware are regarded as superior to other imported lines, and the designs, decorations, and shapes offered are readily acceptable. Prices, however, compare unfavorably with those quoted by Czechoslovakian and French manufacturers, and sales are, as a consequence, limited to the best qualities. Data on imports of plate and sheet glass during 1927 and 1928 are given. There is a comparatively large local production of illuminating glassware, but the import trade is, nevertheless, sufficiently valuable to warrant careful attention. Most of the trade is in the hands of German and Czechoslovakian manufacturers at the present time, the limited business enjoyed by United Kingdom firms being confined to the better quality lines. E.J.V.

Pottery and glass trade in China. ANON. *Pottery Gaz.*, **55** [637], 1145 (1930).—Japan has practically a monopoly of China's market for cheap pottery and glassware, and her propinquity and cheap labor make it difficult for Western industries successfully to compete with her in them. Statistics showing China's import and export in recent years are presented. E.J.V.

Union of European glass manufacturers. ANON. *Giorn. chim. ind. applicata*, **12** [4], 202 (1930).—The "Convention International des Glaceries" has just celebrated its 25th anniversary at Brussels. The association was organized in 1904 by Belgian,

Italian, French, Dutch, German, and Austrian manufacturers. In 1913 it became the "Union continentale commerciale fra le vetrerie," and included all but three firms. Since the war it has been reorganized and has the power to regulate sales, control prices, and stipulate methods of working. M.V.K.

Belgian glass industry. ANON. *Pottery Gaz.*, **55** [637], 1153 (1930).—The planned concentration in the Belgian glass industry is about to be realized. All the glassworks using the Fourcault process and the blown-glass works are to be amalgamated into one company. An agreement will be made with the Libbey-Owens works so as to eliminate the competition of this concern. E.J.V.

Belgian sheet-glass industry. ANON. *Glass*, **7** [3], 113 (1930).—The present difficult situation has been brought about by the enormous increase in the production due to the installation of machines, while at the same time there has been a steady reduction in the available markets. Steps are being taken to remedy the situation. H.W.A.

Society of Glass Technology, January meeting. ANON. *Sprechsaal*, **63** [10], 177–78 (1930); for abstract see *Ceram. Abs.*, **9** [7], 591 (1930). M.V.K.

Glass technical meeting in London. ANON. *Sprechsaal*, **63** [24], 444–46 (1930).—The complete report of the meeting of the German and English glass technical societies in London is given. The following papers were read: E. Berger, "The dependence of the properties of glass on the previous heat treatment." G. Gehlhoff, "Heat currents and temperatures in glass tanks." A. Wendler, "Development and scope of the mechanical manufacture of white hollow glass." E. Zschimmer, "The theory of the composition of glasses." W. L. Bragg, "The structure of silicates." M.V.K.

Modern pottery exhibition. ANON. *Pottery Gaz.*, **55** [637], 1129–35 (1930).—A detailed description of the fine exhibition of modern pottery housed in the King's Hall, Stoke-on-Trent, during May, 1930, is given. It was pronounced to be one of the finest collections of contemporaneous pottery that has ever been placed on view. E.J.V.

Josiah Wedgwood, F. R. S., 1730–1795, potter, inventor, and scientist. HARRY BARNARD. *Brit. Clayworker*, **39** [458], 99–104 (1930).—Incidents in the life of Josiah Wedgwood and the development of the art of potting by him during his lifetime. See also *Ceram. Abs.*, **9** [8], 685 (1930). R.A.H.

International Ceramic Society. ANON. *Pottery Gaz.*, **55** [637], 1115–20 (1930); *Jour. Indian Ceram. Soc.*, **2**, 28 (1930).—At the May meeting, attended by a number of foreign ceramists attending the Wedgwood Bicentenary Celebrations, a proposition was brought forward by R. Barta, of the Czechoslovakian Ceramic Society, that an International Ceramic Society be founded. Reasons for the suggestion, possible objections, replies to these objections, and concrete proposals are advanced. E.J.V.

National clay convention. ANON. *Refrac. Jour.*, **5** [57], 311–14 (1930).—The proceedings of the National Convention of Clay Industries held in May, 1930, at the Palace Hotel, Buxton, and attended by over 100 delegates is given. This year's event was the Third National Convention of the Clay Industries. E.P.R.

Refractories Association of Great Britain. ANON. *Refrac. Jour.*, **5** [57], 318 (1930).—The eleventh annual banquet of the Refractories Assn. of Great Britain was held at Sheffield, May, 1930. E.P.R.

New plant of the "Reinische Kalksteinwerke." PAUL LUDWIGS. *Tonind.-Ztg.*, **54** [42], 699–702 (1930).—"Reinische Kalksteinwerke" for dressing limestone uses American methods of working, has the latest devices, and complete mechanization. M.V.K.

Home of German cement association is rebuilt. ANON. *Pit and Quarry*, **20** [6], 24 (1930).—The Zementhaus, the home of the Deutscher Zement-Bund in Charlottenburg, Berlin, Germany, now appears in a new garb that makes this building one of the

show places of concrete art in Germany. It is particularly interesting for the beautiful light-gray tile on the façade and the ornamental concrete work in the inner court. E.P.R.

Expansion of refractory industries in western, northern, and eastern Germany. BENNO SCHMIDT. *Feuerfest*, **6** [5], 74 (1930).—Detailed account of the expansion in these parts of Germany since 1925. L.T.B.

Danger of a trust in German table glass industry. ANON. *Glashütte*, **60** [13], 215 (1930).—Editorial expressing the opinion that Libbey-Owens seems to be responsible for the tendency of a trust formation in Germany. L.T.B.

Formation of a German-Polish trade association. ANON. *Glashütte*, **60** [13], 215 (1930).—Advantages of such an association are cited. L.T.B.

Economy and working ethics. ANON. *Glashütte*, **60** [13], 209–10 (1930).—Discussion of some of the problems confronting the German glass industry due to post-war demoralization. L.T.B.

German glass technologists visit England. ANON. *Pottery Gaz.*, **55** [637], 1121–28 (1930).—A detailed discussion of the trip taken by members of the Deutsche Glastechnische Gesellschaft to England, as a return of the English visit to Germany in 1928, is given. Illustrated. E.J.V.

Pottery imports into Holland. ANON. *Pottery Gaz.*, **55** [637], 1152 (1930).—Holland imported much more heavy ceramic goods in the first quarter of this year than in the corresponding period of 1929, the respective amounts being 621 T. as compared to 391 T. E.J.V.

Glass industry in India. PARMATMA SARAN. *Jour. Indian Ceram. Soc.*, **2**, 13 (1930).—A brief history of glass industry in India, the causes of failure of glass factories, and the problems to be solved in order to develop the glass industry, are discussed. A.A.

Ford Motor Co. buys Russian glass. ANON. *Pottery Gaz.*, **55** [637], 1135 (1930).—It is reported that the Bolschevischersky factory, near Novgorod, has had an order from Ford for the supply of automobile glass. Before the War Russia had to buy all her requirements in technical glass in foreign countries. E.J.V.

Reorganization of the brick industry in U.S.S.R. O. LECHER. *Tonind.-Ztg.*, **54** [40], 674–76 (1930).—L. describes his impression of the brick industry in the U.S.S.R. where he visited many plants. The bad quality of the production is explained by the lack of experienced technical men. M.V.K.

Russian glass production. ANON. *Pottery Gaz.*, **55** [637], 1153 (1930).—The quantity of glass goods produced in Russia in 1928 to 1929 amounted to 378,100 T., compared with 325,300 T. in 1927 to 1928. The greatest increase was in window glass, *i.e.*, 6%, while the productivity of labor increased by 18.5%. The increase in production is explained by the reconstruction of the tank furnaces in the semiwhite window glass factories; by starting the second plant in the Constantinovsk factory, besides the increased productivity of the tank furnaces serving the Fourcault machines. The expected maximum production of these was 11,000 T. of window glass per annum, but it was found that the Fourcault furnace can produce 13,000 T. per annum. Other detailed data are presented. E.J.V.

Spanish glass industry. ANON. *Pottery Gaz.*, **55** [637], 1120 (1930).—Since 1928 Spanish goblet production has proceeded with unusual regularity, induced by agreements between manufacturers. It appears that the Spanish glass industry is at a turning point. Weakened by the struggle that prevailed for 4 years, 1924 to 1928, which has terminated by the disappearance of a number of factories, it has, at considerable expense had several factories laid idle. Foreign glass is competing closely. E.J.V.

Silver anniversary honoring Alexander Silverman. ANON. *Bull. Amer. Ceram.*

Soc., **9** [7], 216–20 (1930); *Brick Clay Rec.*, **77** [1], 50 (1930); *Glass Ind.*, **11** [7], 168 (1930).—An account of the banquet commemorating the completion of Silverman's 25 years of service in the University of Pittsburgh is given with special emphasis on his contributions to ceramic science. Illustrated. E.J.V.

Meeting of Ohio Ceramic Industries Association. ANON. *Clay-Worker*, **93** [7], 492 (1930); see *Ceram. Abs.*, **9** [8], 685 (1930). E.J.V.

American Iron and Steel Institute. ANON. *Engineering*, **129** [3360], 749–51 (1930).—Thirty-seventh general meeting of the American Iron and Steel Institute, held in New York City on May 9, is described. Brief summaries of seven papers discussed are also included. A.A.

Iron and Steel Institute. ANON. *Engineering*, **129** [3355], 582; [3356], 609–11; [3357], 647–50 (1930).—The proceedings and the papers of the 61st Annual Meeting of the Iron and Steel Institute held May, 1930, at London, are described. A.A.

The World Power Conference. ANON. *Engineering*, **129** [3356], 608–609 (1930). A.A.

Institution of Gas Engineers. ANON. *Engineering*, **129** [3360], 741–42 (1930).—The Sixty-Seventh Annual Meeting of the Institution held in Leeds, England, June, 1930, together with the discussion of the papers read, is described. A.A.

International Congress of Building and Public Works. ANON. *Engineering*, **129** [3359], 706–707 (1930).—A brief description of the topics discussed by the Fifth International Congress of Building and Public Works held during May, 1930, at London, is taken up. These include rationalization; coöperation in industry; financial and credit facilities in dealing with house erection and other contractor's work; apprenticeship; safety provisions in industry; standard conditions of contracts; and education. A.A.

Stoker without pulverizer. ANON. *Brick Clay Rec.*, **77** [1], 28 (1930).—The Pulverzone Automatic Coal Burning System manufactured by the CoKal Stoker Corp., of Chicago, Ill., has been designed or developed to burn coal completely and automatically without the use of a pulverizer. Ordinary screenings are shoveled or fed directly into the hopper end of the Pulverzone in the raw state in which it is received from the coal dealer. Approximately $^2/_3$ of the coal fed from its hopper is burned in suspension, the stoker fuel bed burning only the residual carbon. This intensely hot fuel bed, together with Pulverzone turbulence, accelerates the very rapid combustion of the fine and small-sized coal which is ordinarily much too large to be burned in a pulverized coal furnace which has no stoker grate. The coal not burned in suspension is burned on the CoKal stoker grate, which is an integral part and is located at the bottom of the Pulverzone furnace. Experimental work which is being done in connection with the use of stokers for firing ceramic products indicates that the use of one or two automatic stokers on a kiln instead of 10 or more hand-fired grates is entirely feasible. Several clay products companies have installed the CoKal stoker and made material savings as a result. Illustrated. E.J.V.

Romance of the clay industries. ANON. *Brick Clay Rec.*, **77** [1], 22–23 (1930); *Bull. Amer. Ceram. Soc.*, **9** [8], 241–42 (1930).—The entire program of the Westinghouse Electric & Manufacturing Co.'s radio salute to the clay industry is printed, in which the history of the clay industry is briefly summarized, and Ross C. Purdy speaks on ceramics, acting as the spokesman of the clay industry. E.J.V.

Handling of clay products. ANON. *Brick Clay Rec.*, **77** [1], 24–25 (1930).—Comments from the members of the clay industry arising from the article in the May issue (see *Ceram. Abs.*, **9** [8], 682 (1930)) are printed. E.J.V.

Value of research. ANON. *Blast Fur. Steel Plant*, **18** [5], 834 (1930).—A very considerable factor in the success of Laclede-Christy refractories has been its research

department. Some of the variety of research carried out by the complete ceramic laboratory installed about 25 yrs. ago is described and its effect on the quality of the product discussed. E.J.V.

New 2000 bbl. wet-process cement plant. ANON. *Pit and Quarry*, **20** [7], 47–50 (1930).—The new plant of the American Portland Cement Co., Inc., which is under construction at Foreman, Ark., is about three-quarters completed and could be put into production at any time on three months' notice. Output of this straight-line operation will probably be doubled early in 1931. E.P.R.

Promote Lawrence County clays. ANON. *Brick Clay Rec.*, **77** [1], 50–52 (1930).—A report of the educational meeting sponsored by the Ironton (Ohio) Chamber of Commerce, to bring to the attention of the ceramic industry the rich clay deposits of Lawrence County, at which the speakers on various phases of the industry included T. A. Klinefelter, Ross C. Purdy, J. L. Carruthers, and Wilbur Stout, is given in brief. E.J.V.

New Mellon Institute. ANON. *Bull. Amer. Ceram. Soc.*, **9** [7], 222 (1930); *Nat. Glass Budget*, **46** [4], 3 (1930).—Within the next two years Pittsburgh is to have the finest Temple of Science in the U.S. The Mellon Institute of Industrial Research announced that plans were nearing completion and certain contracts have been awarded for the construction of a new building. The Mellon Institute has in the past been of inestimable value to the glass and other industries that are included in the ceramic field. The scope of work will be greatly increased when the Institute is located in its new home. At present, the ceramic research work will be in charge of E. Ward Tillotson. E.P.R.

Stroitelnyje Materially. ANON. *Feuerfest*, **6** [5], 78 (1930).—Under this title, there has appeared in Russia a new monthly publication on refractory building materials. The first number appeared in January, 1930. L.T.B.

BOOKS, PAMPHLETS, AND BULLETINS

Modern Steelwork. Edited by W. R. GILBERT. The British Steelwork Assn., London, England, 1930. 255 pp. Price 5s. Reviewed in *Colliery Guardian*, **140** [3624], 2257 (1930).—About 100 pages are devoted to illustrated descriptions of important modern steel constructions and a section on "Future Developments in Steel Construction." The rest of the book contains notes on recent British and foreign contracts, an account of the 2nd International Congress on Bridge and Constructional Engineering, and a short chronology of the development of the British iron and steel industry. E.J.V.

Boiler efficiency. ANON. *Black and White*, Oct., 1929; *Pit and Quarry*, **19** [2], 105 (1929).—E. F. Houghton & Co. has published a pamphlet which discusses the over-all gross efficiency of steam-generating plants. E.P.R.

Hydraulics. E. N. DIGWEED. Draughtsman Pub. Co., Ltd., London, 1930. *Mech. World*, **87** [2264], 493 (1930).—This pamphlet covers, in condensed form, the usual textbook range of the subject of hydraulics. As a book of reference it leaves little to be desired as an aid in the general drawing office. E.P.R.

Safe practices in brickmaking. NATIONAL SAFETY COUNCIL. National Safety Council, Chicago. 12 pp. *Clay-Worker*, **93** [7], 480–83 (1930).—This bulletin contains much valuable advice relative to proper care and precautions to prevent accidents in and about the brick plant, dealing with safety practices in the various departments, such as clay winning, machine house, setting, firing, and loading. Excerpts from this bulletin are reprinted. Illustrated. E.J.V.

PATENTS

Coloring mineral granules. HARRY C. FISHER. U. S. 1,766,814, June 24, 1930. That process of coloring granular mineral matter which will withstand a roasting

treatment, which consists in wetting the granules with a water-soluble silicate and heating the granules with agitation through a stage where the silicate becomes intumesced to a stage when it flows into a fused glaze upon the granules.

Coloring mineral matter. HARRY C. FISHER. U. S. 1,766,815, June 24, 1930. That process of forming a glaze on mineral granules, which consists in forming a slurry of glass-forming materials, some of which are insoluble, imposing the slurry upon the granulated mineral matter, and heat treating the product with agitation to a temperature to cause a formation of a glass from the glass-forming materials.

Coloring granulated slate. HARRY C. FISHER. U. S. 1,766,891, June 24, 1930. (1) A granular slate, surface-coated with a body of dehydrated soluble silicate. (2) A process of forming colored mineral matter for surfacing, which consists in crushing natural slate to granular form, mixing the granules with a wet body of soluble silicate and coloring matter, and then treating the resultant mass with heat to permanently cause adhesion of the silicate to the granules with concurrent agitation of the mass.

Forming ceramic articles, etc. THOMAS S. CURTIS. U. S. 1,768,546, July 1, 1930. The process of forming ceramic articles which comprises agitating an admixture of finely divided refractory material and a liquid to produce a turbulence of the admixture and introducing it into a forming-device and maintaining the material therein in a turbulent condition.

Artificial marble. JOHANN KNEJFI AND MARIA MOTYKA. Fr. 655,392; *Pit and Quarry*, **18** [13], 113 (1929).—A glaze containing water 25, soluble glass (40° Bé) 25, K_2CO_3 8, K_2SO_4 5, Ca phosphate 2, coloring materials 35 parts, is applied to plates of substances which can be molded such as asbestos cement, the glaze being hardened by heating in a bath containing water 200, $CaCO_3$ 8, KCl 2, $MgCl_2$ 5, $CaCl_2$ 30, HNO_3 (40° Bé) 6, H_2SO_4 (66 Bé) 6, NaCl 20, $MgSO_4$ 8, and citric acid 5 parts. E.P.R.

BOOK REVIEW

Ceramic Products Cyclopedia. Published by Industrial Publications, Inc., Chicago, 1930. 5th ed. 691 pp. Illustrations, tables. Price $12.00. All of the industries, clay, pottery, enamel, and allied branches which are included under the general head "ceramics" are covered in this cyclopedia.

There are 34 pages of index which have been divided into five sections: (1) a general index covering all information, (2) clay products, (3) enamel, (4) glass, (5) pottery. A catalog of ceramic equipment and material consisting of 181 pages is included.

The editorial section does not endeavor to discuss the ceramic industry as a whole but is devoted to the solution of characteristic problems and the explanation of recent innovations in methods and processes of the trade. This is the best and most authoritative compilation of applied principles of chemistry, physics, and mechanics to ceramic ware production ever published. It should be available as ready reference to every person concerned with ceramic ware production. The only criticism, and this will be lost in the volume of praise that this cyclopedia very well merits, is that references are not given showing sources of the information which the editors have so ably compiled. Also abstracted in *Brick Clay Rec.*, **77** [1], 32–38 (1930). C.H.T.

American Ceramic Congress

Technical Meetings of Seven Industrial Divisions

Educational Exposition of Ceramic Products

Conferences and Social Affairs

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BULLETIN

of the

AMERICAN CERAMIC SOCIETY

A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical, Scientific, and Art Questions, and Promotion of Coöperative Research

Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

E. DEF. CURTIS, MYRTLE M. FRENCH, ERWIN SOHN, W. N. HARRISON	Art, Enamel	J. T. LITTLETON, A. N. FINN, C. F. GEIGER, DOROTHY A. TEXTER, R. F. SHERWOOD, E. H. FRITZ	Glass, Refractories, White Wares	H. D. CALLAHAN, L. A. DOUGHERTY, HOWELLS FRÉCHETTE, W. H. VAUGHAN	Terra Cotta, Heavy Clay Products

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EDITORIALS

WHAT THE AMERICAN CERAMIC SOCIETY SHOULD BE DOING

"What would the AMERICAN CERAMIC SOCIETY do with an income from a million dollar endowment?"

The equivalent of this question was asked yesterday. There was no hesitation in making the answer; "Promote the use of ceramic ware." This answer caused amazement and naturally so because most folks have the notion that the scope of this SOCIETY is limited to academic ceramic science.

No ceramic artist, scientist, or technologist can get very far for himself or his employers until he has as his objective a larger market value of the ware he is producing. A larger market value includes more than quality, decoration, or form; it includes conditions of use and adaptation to the needs of the present day.

The enamelers should have forestalled the decline in sales of enameled kitchen equipment by having developed chemical-resistant and flexure-proof enamels before competitive products forced the issue.

The producers of hotel and restaurant vitreous china should have produced, demonstrated, and promoted their present superior products long before foreign china became the vogue in American hotels, restaurants, and clubs.

The paving brick manufacturer should have developed and firmly established with the engineers the superior wearing qualities and lower maintenance cost of brick pavements with well-drained, solid foundations, and compressible grouting long before the general public got the notion that brick-paved roads were poor quality and dangerous.

The building brick producers should have awakened two decades ago to the fact that other products were being substituted for brick because their producers developed engineering data in the university and federal bureau laboratories that led to the belief that brick was an inferior building material.

Clay roofing tile have been replaced by metal because the architects and builders have not been informed how to place clay tile so they would shed water from above and not drip condensed water from within. There is much to be learned about the proper use of clay roofing tile and about the properties of tile that would make them most serviceable.

The terra cotta maker who has studied the constructional causes of failures and advises with the architects and builders on proper terra cotta installation has done much to win building trade confidence, but he suffers from the failures of those who allow misplacement of their products.

The old time refractory makers would not heed the proven economies of the use of the expensive silicon carbide, mullite, and other products that are superior to clay in refractoriness. Better refractories were needed and they are being produced, but not by the regular refractories producers.

The architects and the engineers together with the producers of building materials other than brick rightfully have a disdain for ceramic engineers because the brick producers will not see the trend to simplification of masonry construction on the modular basis and show a willingness to make brick dimensions to conform. The custom-made masonry products, stone and terra cotta, will replace brick for facings of large buildings if the brick makers persist in being out of step with the modular scheme of building design.

The foundry men, the metallurgists, the steel makers, and other groups of refractories users are justified in their disregard of ceramic engineers and technologists when it is their societies that have to rub the noses of ceramic men into the problems that must be solved in the interest of more efficient use of refractories. It is a discreditable reflection on ceramic engineers and on their CERAMIC SOCIETY that other associated groups are always forcing the issues and making the studies for more serviceable ceramic products.

It is a matter of no little concern, but surely one that should make every ceramist blush, that our Federal Trade Board should finance a campaign at the instigation of representatives of a foreign-made product

to discredit and establish prejudice against a domestic product in all of the large stores throughout the United States, and at the same time attempt to disqualify the official representatives of this SOCIETY as competent witnesses as it did when it made an effort to stop the manufacture and sale of American-made Belleek china. That this SOCIETY had not the standing and power to put a stop to that unwarranted persecution of domestic ceramic manufacturing that was distinctly American in development was a sad commentary on the standing which ceramic engineers have in their own country. We take very little credit and a very small amount of pride in the fact that after the damage was done we forced a decision in favor of our Belleek china manufacturers.

Ceramic engineers, scientists, technologists, and artists should ponder the fact that in large corporations, such as the General Electric, Westinghouse, Western Electric, Norton, Carborundum, Corning Glass, Champion Porcelain, Babcock and Wilcox, Harbison-Walker, du Pont, General Motors, American Telephone, and a score of others, the research organizations focus on development to meet the new needs that are constantly being created, and to better their product for old needs. Delco light would have remained a dream of Kettering's if he and his research associates had not studied the many uses and condition of uses which their product might serve. It is now as much a Delco power as it is light. Delco system it is now called because of the many uses to which Kettering's original invention has been adapted.

Ceramic men cannot afford to dwarf themselves and to limit their services to their employers by not thinking in terms of product, adaptation of their products to old and new uses, and the creation of new products.

Furthermore, no ceramic man can afford to have his AMERICAN CERAMIC SOCIETY function simply and purely as an academic organization or to be without the financial power and prestige to take a leading part in all affairs that relate to the production and use of ceramic products.

This SOCIETY should be activating researches in the universities from which the architects and engineers graduate who will have the decisions to make regarding the use of ceramic building materials. This SOCIETY should be leading in efforts to make these men as ceramic-ware minded as they are now mindful exclusively of concrete and stone.

This SOCIETY should be taking leadership in obtaining and making known to the hotel, restaurant, and club managers the superiority of American vitrified china.

This SOCIETY should be instigating in schools and laboratories those investigations which would establish the economies of brick pavements, vitrified clay sewer linings, and the economies in the use of many other clay products.

The AMERICAN CERAMIC SOCIETY should be qualified to take the organization leadership in problems related to the use of refractories.

The ceramic industries need very badly an organization qualified and financially able to command the attention of associated groups that use ceramic products, and to obtain at the federal bureaus and state universities that share of the research expenditures which the ceramic interest can rightfully demand. The ceramic industries need an organization that can establish with the graduating engineers and architects a ceramic-mindedness comparable to their consciousness of other products. They need a ceramic organization to serve them in things technical, including the technical problems of product development and use in the same way as do many of the national technical societies.

If the AMERICAN CERAMIC SOCIETY had the interest from a million dollar endowment the money would not be used to establish a laboratory or institute; it would be used in activating studies in the adaptation of ceramic products to ever-changing and growing possibilities.

YOUR MONEY SPENT FOR INTERNATIONAL EXHIBIT OF GLASS

The wife of a prominent doctor and one of the foremost woman politicians came to the AMERICAN CERAMIC SOCIETY office last week to see the ceramic exhibits. These ladies are representatives of the middle class who make up the bulk of the chinaware purchasers.

It would not be complementary to the china, the general ware, and the table glassware manufacturers to repeat the statements of these ladies when enlarging their ideas that in America there was not much attractive ware being produced. They admitted having only foreign-made ware for their tables. They could speak readily the names of several foreign china and glass producers but could not recall the name of one American firm. When prompted, they did recall having heard the names of three or four but queried whether those concerns did not produce exclusively for the syndicate stores.

They were asked if they knew what material was used to face the A. I. U. building in Columbus. They did not know that it was terra cotta exclusively. Then they asked about terra cotta and its use.

These two women also asked the very pertinent question "Why is it that our museums and stores feature foreign-made ware?" They told of traveling exhibits that are constantly being shown by museums in the large cities. These women are, generally, well informed; they are above the average.

"What is ceramics;" "is there any science in brickmaking or brick using?" and many like questions are being asked by people who are generally well informed.

PAPERS AND DISCUSSIONS

AN ACCURATE AND FLEXIBLE CONTROL OF KILN HEAT

By F. H. Johnson

Pyrometers give the temperature increases. Temperature measurement, no matter how exact, is not in itself sufficient evidence from which to judge the finishing point of any clay ware. A clay may be brought to the same degree of vitrification at different temperatures in different hours, if any factor in the process is allowed to vary.

Pyrometric cones, invented by Seger, are quite widely used as a visual means of determining heat treatment in ceramic kilns. This is a series of silicate mixtures which melt in progressive order, and is used as a scale for comparison in the firing process. The comparison is in reference to the melting point of the cones.

Accurate control is only made possible by obtaining information during any stage of the firing at any point within the kiln.

The principle of kiln control found in the Forester system was originally used by Wedgwood, and later perfected by Leonard Forester. Heat effect is determined by the measurement of shrinkage of specially standardized clay materials. It comprises only two units, the clay test piece in the form of a wedge called the Forester Key and a special gage which accurately measures the shrinkage of the key.

A schedule of temperatures compares the points on the gage with pyrometric cones and pyrometers.

As the rate of shrinkage is dependent upon the rate of heat application, so also is the maturity of the ware dependent upon heat application, and is affected by the condition of the atmosphere in the kiln, whether oxidizing or reducing, this demanding various schedules for the conditions existing.

The close similarity in the behavior of Forester Keys during the firing procedure to the behavior of the clay ware gives this system many valuable advantages.

It affords a complete and accurate record of the condition of the product at all times and from as many sections of the kiln as is desired.

It indicates faults in the firing and inequalities in various parts before the firing has proceeded far enough to do damage and directs attention to the part of the kiln where the correction may be made.

It will detect unscrupulous manipulation of the firing. Reduction or flashing will show on the keys when drawn.

After a key is drawn it is a permanent record. A set of them comprises a heat chart to be followed and thus makes it possible to duplicate a previous firing which had produced exactly the desired ware.

The wedges are not influenced by slight disturbances such as electric

storms, changes in outside temperatures, sulphuring, or sudden drafts, but are affected only as the ware itself is affected and are a true comparison to the ware itself.

The cost per kiln operation is exceptionally low, not exceeding two dollars for the maximum firing period. The investment is low, consisting entirely of keys purchased.

Operation of this system is not complicated and is quickly comprehended. Its value as an aid to firing is quickly appreciated. It assures a positive check on heat progress.

How Used

After determining the rate and total amount of shrinkage required, a firing schedule is developed.

The keys are placed in each of the four draw sections, at the top of the setting, midway and bottom of courses, saggers, or draws. The number of keys placed for each draw will depend upon the length of firing and frequency of drawing. In heavy clay products and refractories with a schedule of one to ten days, draws should be made at eight-hour intervals. In wall tile, pottery, etc., with shorter firing time, four-hour draws should be made and a sufficient quantity of keys placed to cover the period. Keys should also be placed in the middle of the kiln to be measured when the kiln is drawn. The keys to be drawn as the firing progresses are placed as far in the kiln as possible, uniformly distant from the wall of the kiln, and so located that they may be conveniently drawn with a hooked trial rod.

At the end of the watersmoking a key is drawn from each location and measured on the gage. If the readings of the bottom keys register one point or more, which would compare to cone 013 or approximately 800°C, it shows conclusively that the combined water and carbon have been driven out and that it is safe to advance the firing.

Keys are then drawn at definite intervals. If any section of the kiln is not on the firing schedule, attention can be given to that section. A gradual and uniform rise in heat is accomplished and a sudden rise in temperature avoided. Inequality in key readings will call early attention to the poor heat distribution.

When the number of degrees of shrinkage that is required for maturity of the particular ware has been determined, each kiln may be completed when this point is indicated by the keys drawn.

Summitville Face Brick Company
Summitville, Ohio

ACTIVITIES OF THE SOCIETY

REPORT OF ENAMEL DIVISION STANDARDS COMMITTEE, 1930[1]

The Committee met at Toronto, February 17, 1930, carefully going over the three methods which were standing as tentative. These were (1) the method for fineness of wet-milled enamels, (2) for deformation temperature of enamel, and (3) for resistance of sheet-steel enamel to deflection.

I

The Tentative Method for Fineness of Wet-Milled Enamel was recommended to the Division for adoption as a Standard Method. This recommendation was approved by the Division with the addition of a note, which in no way affects the sense of the text but calls attention to certain necessary precautions. The method now appears in the record as follows.

Standard Method for Fineness of Wet-Milled Enamel

Sample The enamel to be tested should be stirred thoroughly to produce uniformity. A sample containing 100 grams of frit should be weighed. This in grams corresponds to the total mill charge, including water, for 100 pounds of frit.

Sieves A No. 40-protection sieve should be placed above the testing sieve. The testing sieve should be either a No. 100, 200, or 325, depending on the fineness of the enamel being tested. If, on a trial run the residue retained on a No. 200 sieve as testing sieve is over 25 grams, a No. 100 should be used; if the trial residue on a No. 200 is less than one gram a No. 325 should be used; if the residue on a No. 200 is within the range of 1 to 25 grams, that sieve should be used. The above sieve numbers refer to the United States Standard Sieve Series.

Testing The weighed sample should be poured onto the upper (protection) screen and carefully washed through the two screens until no enamel can be detected in the washings. Nothing other than coarse, unground particles should be retained on the protection screen. The lower (test) screen with its residue should be thoroughly dried until the residue thereon easily moves about as a dry powder when the sieve is shaken. The sieve should be tapped gently until less than 0.1 gram passes through on a minute's tapping.

Weighing The residue should be transferred to a balance and weighed to the nearest 0.1 gram. The weight thus determined should be taken as the index of fineness of the enamel in terms of the number of testing screen used.

NOTE: Testing sieves of the finer sizes have, in a number of instances, been found in error far more than the commercial tolerances permit. This is especially true of old sieves, due to wear and to the corrosive influence of the laboratory atmosphere, but may sometimes be true of new sieves. Reasonable precautions should be taken by the user to assure himself that his sieves are accurate.

II

The Tentative Method for Deformation Temperature of Enamel was also recommended to the Division for adoption as a Standard Method. A slight change in the accompanying drawing was made.

The recommendation was approved by the Division and now appears as follows.

Standard Method for Deformation Temperature of Enamel

This method is applicable to frits and milled enamel.

(1) **Preparation of Sample** A representative sample of frit or milled enamel should be thoroughly dried and ground in a porcelain pebble mill to pass a 150-mesh sieve.

[1] Received July, 1930.

(2) Test Pieces The test pieces should be the size and shape of pyrometric cones: tetrahedra $^{5}/_{8}$ inch along the edge of the base and 2 $^{1}/_{2}$ inches high. They should be molded from a mixture of the powdered enamel and water with enough organic binder to produce the necessary plasticity and cohesion. The test pieces should be thoroughly dried upon removal from the molds.

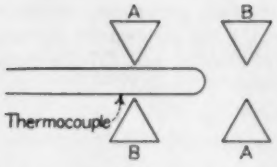

FIG. 1.

(3) Mounting The test pieces should be mounted on a plaque of asbestos board or strip of steel which has been coated with enamel. The base of the test pieces should be embedded in a plastic mixture such as sand, clay, and water, and their troweled faces should make an angle of 82° with the plaque. One or two pairs of test pieces from one or two enamels should be placed on a given plaque in the manner shown in Fig. 1, permitting the end of the thermocouple to be equidistant from the tips of each pair of test pieces without being touched thereby during deformation. The mounting should be thoroughly dried before being placed in the furnace.

(4) Furnace The furnace should be one which will give a definitely oxidizing atmosphere. It should be subject to accurate temperature control through the range 800 to 1600°F. It should be equipped with a pyrometer, the thermocouple of which should terminate near the center of the horizontal plane of the furnace and one inch or farther below the top. The pyrometer should be of such type as to afford an accuracy of ±10°F, with proper corrections for cold end temperature.

(5) Placing of Test Pieces in Furnace The mounting should be placed in the furnace in such a manner that the tips of the test pieces from each enamel are $^{1}/_{2}$ inch above the center of the thermocouple and horizontally equidistant therefrom.

(6) Rate of Heating The furnace should be at or below 800°F when the test pieces are placed therein. The rate of heating should be the following:

Start	800
10 minutes	1020
20 "	1150
30 "	1260
40 "	1370

(7) Observations The "starting time" should be the instant that the pyrometer indicates a temperature of 800°F on recovering from the drop in temperature caused by the introduction of the test pieces. Each test piece should be observed separately with reference to the temperature of initial bending of the tip and final bending of the tip to the level of the base. The first observations should be averaged as the "starting temperature" and the final as the "deformation temperature." The difference between the two should be taken as the "deformation range." Two or more closely checking runs should be averaged for final results.

III

The Tentative Method for Determining the Resistance of Sheet-Steel Enamel to Deflection appeared to require considerable revision. In spite of the fact that it would call for some additional work in carrying out the test, it was agreed that the thickness of the enamel coating under test should be expressed both in terms of weight and thickness. The test was presented in the following form, and was approved by the Division as a revised tentative method.

Tentative Method for the Determination of the Resistance of Sheet-Steel Enamel to Deflection

Testing Machine The machine used in the test shall embody the essential details of that shown as Fig. 7, Report of the Enamel Division Standards Committee 1927–28.[2]

Preparation of Test Pieces The metal base should be strips from 22-gage enameling stock, cut 2 in. wide and 12 in. long. For convenience in handling during processing, a $^{1}/_{4}$-in. hole may be punched near one end of the strip.

[2] *Bull. Amer. Ceram. Soc.*, **7**, 362 (1928).

The numbered strips should be carefully pickled and after drying weighed to the nearest $^1/_2$ gram and calipered to the nearest 0.001 in. They should be dipped in commercial ground coat, dried, fired, weighed, and calipered. Strips which do not appear to represent good local practice should be rejected. Two coats of the enamel to be tested should be applied. Before firing each cover coat, the edges should be brushed back $^1/_8$ in. to prevent the forming of a bead. Pieces showing excessive warpage or having firing tool marks near the center should be rejected. After enameling, the strips should again be weighed and calipered as before, and by subtracting the weight and thickness in ground coat, the weight and thickness of the cover enamel are determined. For use in the test only strips bearing cover enamel within $\pm$ $^1/_2$ gram and $\pm$ 0.001 in. of the amount determined upon should be used.

Testing With the center roller dropped to a sufficiently low position, test pieces should be so placed in the machine that the back ends will rest against the under side of the back roller with the front ends not touching the front roller. The position of the center roller should then be advanced until one or more of the strips just touches the under side of the front roller. The dial should be read and this reading taken as the initial reading for the strips thus making contact. The center roller should then be advanced at the specified rate and the dial readings taken where each of the other strips makes contact.

From the time that the first strip makes contact until the last strip has failed, the center roller should be advanced at the uniform rate of 0.02 in. every two minutes.

After the last strip has made contact the surface of each piece over the center roller should be coated with a smear of lampblack in vaseline, and just before each advance in position the surface should be rubbed carefully with a cloth to note whether or not a crack has been produced. Care should be taken to confine this rubbing to the area immediately over the center roller, otherwise pressure on the test pieces may affect results.

When the first significant crack appears on a given strip, the dial should be read and the value recorded as the final reading for the strip involved. (The term "significant crack" should be taken to mean a crack extending more than half-way across the test piece.)

The difference between the initial and final readings for a given strip, expressing the number of hundredths of an inch of deflection to produce failure, should be taken as the deflection value for the piece.

Deflection Value The deflection value for a given enamel should be the average results from not less than six individual test pieces. The record of the test should include the average weight and thickness of the ground and cover coats.

NOTE 1: In addition to the information afforded by the deflection to produce first crack, it is of value to continue the advance of the center roller noting the behavior of the enamel under the more extreme deflection.

NOTE 2: Two procedures are recognized as being available depending on whether the test is being used in connection with shop control or with development research.

(A) In shop control it is recommended that each shop determine the weight and thickness of enamel on the standard test piece corresponding to the thickness used in commercial practice, and that this weight and thickness be adhered to in the preparation of test pieces. (Information now available suggests a weight range of from 7 to 10 grams as covering practice for two coats of white enamel.)

(B) In connection with development research, where more complete information is desirable, it is recommended that for each enamel there be prepared test pieces of three or more different thicknesses, covering a range from well below to well above the normal thickness. The average deflection of each set plotted against the corresponding thicknesses results in a curve which affords a truer picture of the behavior of the enamel than does a determination on only one thickness.

R. D. COOKE, *Chairman*
E. P. POSTE
W. N. HARRISON
B. A. RICE

TWO IMPORTANT LETTERS

Your Secretary has not heretofore published his letters. This has been a mistake. He has ambitions for the SOCIETY, and he has ideas on policies which the members might well know. Here are two letters.

2525 N. High St.
Columbus, Ohio
August 13, 1930.

Mr. R. R. Danielson,
Metal & Thermit Corporation,
120 Broadway,
New York, N. Y.

My dear Ralph:

Yours August 11
Report of Research Committee
Enamel Division

It is very regrettable that this SOCIETY has not the financial means and the support of industrial executives that would permit it to take a more active part through committees in the origination and prosecution of researches conducted at universities and bureaus. Committees of this SOCIETY should be working closely by means of frequent meetings with the several laboratories, and should be furnishing materials and securing fellowship fees. The universities, the bureaus, and the surveys throughout the country have the facilities, the organization, and the desire to prosecute ceramic research. A great deal of public money which is now being otherwise spent, could be directed to ceramic research provided the ceramic industries, through some agency, would assist in formulating and prosecuting the investigations.

Our Art Division should be collaborating with the museums and the art schools, not only in the matter of exhibits, but in ceramic art training. A great deal could be done in making the citizens of the United States conscious of the high attainments in ceramic art ware and household ware if some agency could be working with the museums and the schools. We could thus be obtaining a very considerable amount of money that is now being used for other groups. Each time I hear of an exhibit of foreign-made china and glass being sent to the chief museums of this country, under the auspices of the United Art League and the museums, my blood boils, but we cannot protest, and the information has come to me that if the American potters would take the initiative in coöperating with the museums and the schools in any such measures as do the importers of foreign ware, they would be glad to coöperate in the matter of traveling exhibits.

This matter has been gone into quite extensively by Mr. Curtis, Chairman of the Art Division, and member of the Board of Trustees from the Art Division, but he has not succeeded in getting anywhere because of the lack of funds. He has spent a very considerable amount of his own money in making contacts in the East.

The several technical Divisions should be contacting with the Bureau and with the schools, with frequent committee meetings, furnishing supplies, and in part financing the salaries. The Glass Division has done this during the past three years. Their first sum of money raised was $8000. They have raised more money and are continuing the investigations at the Bureau, but the committees from the Glass Division are not following this up in any such fashion as they should because of lack of funds. All of the money they have raised is being used for payment of salaries and necessary supplies. They could use three or four thousand dollars annually. And this situation prevails with each of the Divisions.

It is a shame and a disgrace to the AMERICAN CERAMIC SOCIETY that the ceramic industries are not supporting this SOCIETY in a way that would enable it to take the leadership in investigations of refractories for specific purposes and for enamels for definite purposes and many other like problems, rather than to leave these to the initiative of the organizations of users of ceramic products.

It makes me blush with shame when the AMERICAN CERAMIC SOCIETY is called upon to look into a matter that it has to limit its activity to merely collecting the existing information, and has to leave it to other associations to organize and to prosecute the investigations.

Compared to what it should be, this SOCIETY is a "piker" organization. It has not visioned its possibilities and responsibilities. It has not made plain to the ceramic trade associations that it is not competitive with them and is not trespassing in the least on the trade association provinces when it makes studies of product qualities as related to product uses, and the development of products for specific purposes, new and old. There naturally is an overlapping in scope and province between the trade associations and this SOCIETY just as there is an overlapping in any well-organized manu-

facturing corporation between the research, sales, and production. An AMERICAN CERAMIC SOCIETY that is strictly academic would be almost valueless. This SOCIETY must be aggressively participating in the studies of products, and the uses of products, if it is going to be of any value to ceramic industries. It must fearlessly take up the masonry problems that will eliminate the present leaky, weak, and wholly undesirable brick walls that are found in many prominent buildings, notably the Graybar of New York. This SOCIETY should have had the leadership in the study of boiler refractories, rather than to have left it to the A.S.M.E.

I am thoroughly in accord with the idea that ceramic engineers and technologists should be studying production problems and production economies. Methods of treating materials, forming ware, drying and firing, and even the problems of plant routing are very obviously within the province of the ceramic technologists and engineers; hence of this SOCIETY. I would not lessen the attention and influence that is being given to these things. They are the first duties of ceramic engineers and technologists. Lately we have put more stress on the importance and the obligation of ceramic engineers and technologists studying products, their uses, and their adaptation for uses not now being served, because this has not in the past been considered within the province of the ceramists.

The Chicago Exposition and the one we are to have in Cleveland this winter are for the purpose of educating the public and ourselves about the attainments in America in ceramics, and to give inspiration and ideas along development lines. The ceramic scientist, technologist, or engineer who remains all the while at the plant and never sees the trade, never has opportunity to study the uses of his product or the possibilities of new products from his materials and plant; and the company which does not permit him to make these studies, is not realizing on his capacities and investments. I have just heard of two very fine fellows, whom I know to be excellent ceramic technologists, having been released from an important corporation because they had not shown initiative and were not snappy. Possibly it was against their nature, but most likely they were never encouraged to develop initiative and snappiness, and to assume leadership in the development of new products, new varieties, and new uses.

This SOCIETY has a much larger opportunity than it has ever realized, and it will not realize these opportunities until its members are awakened to the full scope of its possibilities of service to the industries, and on the other hand, until the industries will realize that in this SOCIETY they have no competitor of the trade associations, but an organization that should be doing a far larger work than merely to collect and publish academic information on materials, mixtures, and processes.

Yours very cordially,

ROSS C. PURDY,
General Secretary

RCP:ZW
cc: Members, Board of Trustees
Chairmen and Secretaries of Divisions

How Your Business Ills Can Be Cured

2525 N. High St.
Columbus, Ohio
August 13, 1930.

Fellow Member:

Take a firm stand against pessimism. There is nothing basically wrong. The ills are of our own imaginations and our own management failures.

The retail business is within 3% of the peak. Only 2% of the laborers are unemployed. The dividends and surplus statements do not reflect hard times. Employment capacities were 95% normal when at the lowest and manufacturing is picking up. There were at the last report $29,000,000,000 in savings accounts or $232.00 for each man, woman, and child in the U. S. A. More life insurance was written last month than in any previous month. Over $200,000,000 is being spent this year in industrial research. There is nothing basically wrong except the difficulties which have arisen from the unprecedented industrial growth. Herein lies our management failures.

The concern and the person who has not been fortified by surplus finances is feeling the present pinch. Those who have imagined that they knew and were putting into

practice the best information extant without at the same time subscribing to the sources of information and keeping in personal touch with their aggressively progressive fact-finding fellows are now without a knowledge surplus; they have no way to turn; they feel that they must patiently accept hard-time reverses. Not so those who are go-getters after knowledge.

You cannot afford to be without personal affiliation with the AMERICAN CERAMIC SOCIETY. You cannot afford as long as you are engaged in ceramics to let this effective fact finding and distributing agency be without adequate support.

Come now—renew your support.

NECROLOGY

D. B. Hall

Donald B. Hall who has been for the past three years employed by the Structural Clay Tile Association as Research Engineer, at the Roseville Plant, O.S.U., died in the Zanesville Hospital of pneumonia August 3. The funeral services were held in Roseville, Monday and the body was taken for burial to Hornell, Mr. Hall's boyhood home.

There is a widow and two small children.

Mr. Hall's death will greatly handicap the Structural Clay Tile Association's research for some time. Mr. Hall's particular contribution was the development of machinery for the production of light-weight structural material.

NEW MEMBERS RECEIVED FROM JULY 1 TO AUGUST 1

CORPORATION

Ukrsylicate of Kharkoff, T. L. Krutko (voter), Kharkoff, U.S.S.R.

PERSONAL

Frank G. Heck, Research Assistant, Department of Ceramics, Rutgers University, New Brunswick, N. J.

Richard O. Hummel, 616 Fordham Parkway, Bay Village, Ohio; Asst. Supt., Cowan Potters, Inc., 19633 Lake Road, Rocky River, Ohio.

Frank A. Lobee, Jr., 841 Elmwood Ave., Buffalo, N. Y.; Sales Representative, McLeon & Henry Co., Troy, N. Y.

Membership Workers' Record

PERSONAL		CORPORATION	
A. E. Baggs	1	Office	1
R. G. Mills	1		
S. F. Walton	1	Grand Total	4
Total	3		

ROSTER CHANGES IN JULY

CORPORATION*

Wheeling Steel Corp., H. F. Zarth (voter), Portsmouth, Ohio. (Carl Burkhalter (voter)).

PERSONAL*

Callinan, Edward E., 103 Jacoby Street, Norristown, Pa.; E. J. Lavino and Co., Plymouth Meeting, Pa. (1984 N. 4th St., Columbus, Ohio.)

* Addresses within the parentheses ( ) represent the old address.

These roster changes which appear each month may be checked against the complete Membership Roster which was published in the July, 1929, issue of the *Bulletin*. Copies of this issue may be obtained from the Secretary's office, price $2.00.

Cunningham, Geoffrey E., Clarkson College of Technology, Potsdam, N. Y. (Iowa State College, Ames, Iowa.)
Foster, Edwin S., 3317½ Austin St., Houston, Texas. (P. O. Box 542, Lincoln, Calif.)
Gates, Wm. D., Crystal Lake, Ill. (228 N. La Salle St., Chicago, Ill.)
Grout, J. R., Jr., Route 3, Danville, Ill. (Coffeyville, Kansas.)
Hertzell, E. A., Harbison-Walker Refractories Co., Chester, Pa. (3415 East St., Pittsburgh, Pa.)
Howell, Harriet, 3 Springland, Toronto, Canada. (355 Winchell Rd., Shaker Heights, Ohio.)
Hunt, Frank S., Batchelder Wilson Co., Los Angeles, Calif. (Rossman Corp., Beaver Falls, Pa.)
Kates, Paul G., 501 N. Central Ave., Chicago, Ill. (415 25th Ave. S., Nashville, Tenn.)
Lampe, Chester E., 728 South 8th St., Quincy, Ill. (4827 Melrose St., Bridesburg, Philadelphia, Pa.)
Meyer, F. R., 247 N. Indiana Ave., Kankakee, Ill. (7683 Carswold Drive, Clayton, Mo.)
Parsons, Joseph R., 23 S. Damen Ave., Chicago, Ill. (Box 3104, Raleigh, N. C.)
Sample, Leslie, 2029 North Nevada Ave., Colorado Springs, Colo. (Van Briggle Pottery.)
Sauereisen, Fred, 2308 Main, Sharpsburg, Pa. (116 S. Sheridan Ave., Pittsburgh, Pa.)
Seabright, Edward C., Y.M.C.A., Room 432, Hamilton, Ohio. (215 15th Ave., Columbus, Ohio.)
Spiker, John E., 1120 Second Ave., Salt Lake City, Utah. (Hawthorne, Calif.)
Spires, Stephen T., 53 Trevalley Rd., Revere, Mass. (329 Edgewood St., N. Canton, Ohio.)
Sutton, W. J., Fukien Christian University, Foochow, China. (Cornell Univ., Ithaca, N. Y.)
Walsh, Edward R., 937 Cross Ave., Elizabeth, N. J. (605 E. Chestnut St., Louisville, Ky.)
Webster, Charles E., 726 Minnesota Ave., Apt. No. 2, South Milwaukee, Wis. (2215 Elmwood Ave., Springfield, Ohio.)
Williams, George A., 15 Remsen Ave., New Brunswick, N. J. (Wunderlich, Ltd., Sydney, Australia.)
Young, C. B., Mineral Brick Co., Mineral City, Ohio. (New Lexington, Ohio.)

NOTES AND NEWS

CERAMIC SCHOOL NOTES

New York School of Clayworking and Ceramics

Of the fourteen engineers graduating in June, those who have so far obtained positions are located as follows:

Leland Armstrong, Carborundum Co., Niagara Falls, N. Y.
Robert Bassett, United States Gypsum Co., Oakfield, N. Y.
William Fabianic, Fellowship North Carolina State College, Raleigh, N. C.
Don C. Lynn, Koppers Laboratory, Mellon Institute, Pittsburgh, Pa.
James C. Mays, Carborundum Co., Niagara Falls, N. Y.
R. Karl Smith, Fellowship University of Illinois, Urbana, Illinois
Ernest H. Spencer, Harbison-Walker Refractories Co., Hays, Pa.

The others are making arrangements but are not yet settled.

Some of the men who secured summer jobs were: Eugene Bryant, Cambridge Tile Co., Covington, Ky.; Harold Huffcutt and Meredith Barton, Hanley Brick Co., Summerville, Pa.; Raymond Shremp, Fiske & Co., Darlington, Pa.; and Earl Beeton, Buckeye Ceramic Co., Cincinnati, Ohio.

The recently formed Alfred Ceramic Alumni Association has published the first issue of a news bulletin called *Activities of Interest to Alfred Ceramic Alumni*. The officers of this organization are:

President, J. F. McMahon, Ottawa, Canada
Vice-President, R. F. Sherwood, Syracuse, N. Y.
Secretary and Treasurer, L. P. Collin, Ottawa, Canada
Executive Committee { C. Forrest Tefft, Columbus, Ohio; H. B. DuBois, East Liverpool, Ohio

The Association is organized for the purpose of keeping in touch with one another and of furthering activities of benefit to the Alfred Ceramic School and University. The bulletin contains letters from President B. C. Davis of the University, Director C. F. Binns of the Ceramic School, C. R. Amberg, Professor of Ceramic Engineering, and M. L. Fosdick, Professor of Ceramic Art. It is a worthy effort and a decided step in the direction of united effort for the good of the school.

The local chapter of Beta Pi Kappa, the honorary ceramic fraternity takes pleasure in announcing the election of the following men as honorary members:

G. A. Bole, Ohio State University
J. B. Shaw, Pennsylvania State College
P. E. Cox, Iowa State College

Among the commercial tests made in the laboratory of the School this spring were a consignment of chemical porcelain from Colorado and a new china clay from Georgia.

The Campus is a scene of much activity this summer with construction under way for a Social Building and a Men's Dormitory. Plans are developing rapidly for the new $175,000 Ceramic Building.

The Department of Applied Art closed a very successful year with an exhibition of pottery, textiles, and drawing work during Commencement Week. Many of the students of applied art are acting as pottery counselors in girls' camps this summer. There is an increasing demand for this type of teacher. A good many of the graduates in applied art have accepted positions teaching arts and crafts for the coming year. Among those who have commercial positions are:

Bruce Thorngate (graduated with honors), Overglaze Department of Onondaga Pottery Co., Syracuse, N. Y.
Paul Gardner, Design Department of the Steuben Glass Works, Corning, N. Y.

Alfred was well represented at the National Convention of Settlement Workers held in Rochester, N. Y., in June. One of the sessions was given over to the importance of pottery taught in Settlement Houses and was conducted by Miss Ruth Canfield, teacher of pottery at Henry Street Settlement, New York. Papers were read by Mrs. M. M. French of The Hull House Kilns, Chicago, Miss Ruth Claire of Tau Beta House, Detroit, Mich., and Miss Elsie Binns of Alfred, N. Y. The representatives from Alfred were Miss Helen Post, Senior in Applied Art and Miss Ruth Whitford, Secretary to Director Binns.

The Alfred Summer School of Pottery opened on July 7 for six weeks with twenty-three students registered. C. F. Binns is consulting professor and lecturer. C. M. Harder is in charge of laboratory practice assisted by Luke Beckerman of Chicago.

FELLOWSHIP IN CERAMICS AT WEST VIRGINIA UNIVERSITY

A fellowship in ceramic research has recently been made available in the Department of Chemical Engineering, West Virginia University. The fellowship will pay $1200 over a period of ten months beginning September 1, 1930, and will carry with it a remission of tuition (which amounts to $150 for two semesters for non-residents). The applicant should have a bachelor's or a master's degree in chemical or ceramic engineering, but it is possible that a worthy applicant with a corresponding degree in some other course may be accepted.

If the recipient's work is satisfactory, he may be able to receive his master's degree in one year, if he is a holder of a bachelor's, or doctor's degree in two years, if he is a holder of a master's degree. It is possible that the fellowship will be continued for one or two more years if the recipient becomes a candidate for the doctor's degree.

If the recipient of the fellowship has no research problem of his own he will be given a problem in the study of the properties of clays, but more attention will be given to selecting a man with marked ability than to selecting one to work out a definite problem.

BRANDS OF REFRACTORIES: EIGHTH EDITION

Announcement is made of the issuance of the booklet, Brands of Refractories, by the American Refractories Institute. This booklet lists every known manufacturer of fire brick in the United States and Canada, together with a list of the brand names of their products. The publication is in its eighth edition. Copies may be secured from the Secretary of the American Refractories Institute, Oliver Bldg., Pittsburgh, Pa., at a charge of 25 cents each.

CALENDAR OF CONVENTIONS

Organization	Date	Place
American Assn. for the Advancement of Science	December 29, 1930 to January 3, 1931	Cleveland, Ohio
AMERICAN CERAMIC SOCIETY	February 22–28, 1931	Cleveland, Ohio
American Chemical Society	September 8–12	Cincinnati, Ohio
American Concrete Institute	February, 1931	Milwaukee, Wis.
American Electrochemical Society	September 25–27	Detroit, Mich.
American Engineering Council	October	Washington, D. C.
American Gas Assn.	October 13–17	Atlantic City, N. J.
American Institute of Mining and Metallurgical Engineers	September 11–13	Pittsburgh, Pa.
American Mining Congress		
Western Division Meeting	October 13–18	El Paso, Texas
Annual Convention	December 1–6	Washington, D. C.
American Refractories Institute	October	Atlantic City, N. J.
American Society of Mechanical Engineers	October 13–15	French Lick Springs, Ind.
American Society for Steel Treating	September 22	Chicago, Ill.
American Society for Testing Materials	June 22–26, 1931	Chicago, Ill.
American Standards Assn.	September, 1930	New York, N. Y.

Assn. of Iron and Steel Electrical Engineers	June 15–19, 1931	Cleveland, Ohio
Feldspar Grinders' Institute, Inc.	September 27	Spruce Pine, N. C.
Grinding Wheel Mfrs. Assn. of U.S. and Canada	September 19	Shawnee on Delaware, Pa.
Gypsum Assn.	September 9	Chicago, Ill.
Illuminating Engineering Society	October 7–10	Richmond, Va.
Mining and Metallurgical Society of America	September	New York, N. Y.
National Academy of Sciences	September 18–23	Berkeley, Palo Alto, and Pasadena, Calif.
National Assn. of Mfrs. of Heating and Cooking Appliances	May, 1931	New York, N. Y.
National Electrical Exposition	October 6–11	New York, N. Y.
National Exposition of Power and Mechanical Engineering	December 1–6	New York, N. Y.
National Glass Distributors Assn.	December 2–4	Pittsburgh, Pa.
National Paving Brick Mfrs. Assn.	February 4–6, 1931	Pittsburgh, Pa.
National Safety Council	Sept. 29–Oct. 4	Pittsburgh, Pa.
New Jersey Clay Workers Assn.	December	New Brunswick, N. J.
Optical Society of America	October	Charlottesville, Va.
Taylor Society, Inc.	December 3–5	New York, N. Y.
Tile & Mantel Contractors' Assn. of America, Inc.	April 14–17, 1931	Milwaukee, Wis.
Western Canada Brick & Tile Assn.	December	Saskatoon, Sask.
Wisconsin Clay Product Mfrs.	October	Madison, Wis.

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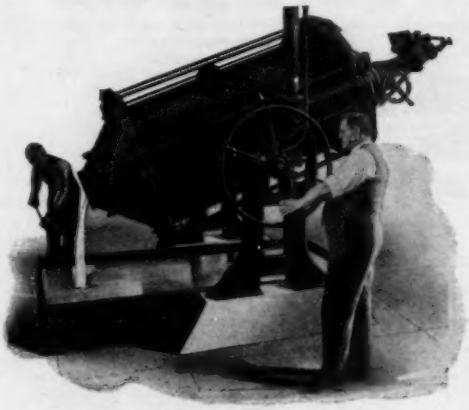

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Hommel, O., Co.
Pennsylvania Salt Mfg. Co.
Roessler and Hasslacher Chemical Co.

Aluminum Oxide (Fused)
The Exolon Co.
Harshaw Chemical Co.

Alundum (Refractory Products)
Norton Co.

Ammonium Bifluoride
Harshaw Chemical Co.
Hommel, O., Co.

Ammonium Carbonate
Harshaw Chemical Co.
Hommel, O., Co.

Antimony Oxide
Harshaw Chemical Co.
Hommel, O., Co.
Roessler & Hasslacher Chemical Co.

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Chambers Brothers Co.

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Philadelphia Drying Machinery Co.

Automatic Temperature Control
Brown Instrument Co.
Leeds & Northrup Co.

B

Ball Mills
Hommel, O., Co.
McDanel Refractory Porcelain Co.
Mueller Machine Co., Inc.

Ball Mills (Laboratory Type)
Hommel, O., Co.

Barium Carbonate
Harshaw Chemical Co.
Hommel, O., Co.
Roessler & Hasslacher Chemical Co.

Barytes
Harshaw Chemical Co.
Hommel, O., Co.

Batts
Carborundum Co. (*"Carbofrax Aloxite"*)
Norton Co. (*"Alundum-Crystolon"*)

Bitstone
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Golding Sons Company
Harshaw Chemical Co.
Potters Supply Co.

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Carborundum Co.
E. J. Lavino and Company
Norton Co.

Boats, Combustion
Norton Co.

Borax
American Potash & Chemical Co.
Drakenfeld & Co., B. F.
Hommel, O., Co.
Harshaw Chemical Co.
Pacific Coast Borax Co.
Roessler & Hasslacher Chemical Co.

Borax Glass
Harshaw Chemical Co.
Pacific Coast Borax Co.

Boric Acid (Anhydrous)
Hommel, O., Co.
Pacific Coast Borax Co.

Boric Acid (Crystal, Granular or Powder)
American Potash & Chemical Co.
Drakenfeld & Co., B. F.
Harshaw Chemical Co.
Hommel, O., Co.
Pacific Coast Borax Co.

Brickmaking Machinery
Chambers Brothers Co.

Bricks (Refractory)
Carborundum Co. (*"Carbofrax Aloxite"*)
Harbison-Walker Refractories Co.
E. J. Lavino and Company
Norton Co. (*"Alundum-Crystolon"*)

C

Carbofrax (Refractory Products)
Carborundum Co.

Carbolon (Refractory Products)
The Exolon Co.

Carbonates (Barium, Lead)
Harshaw Chemical Co.
Hommel, O., Co.
Roessler & Hasslacher Chemical Co.

Caustic Soda
Harshaw Chemical Co.
Pennsylvania Salt Mfg. Co.

Cements
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Norton Co.

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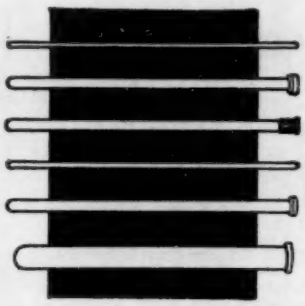

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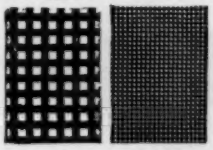

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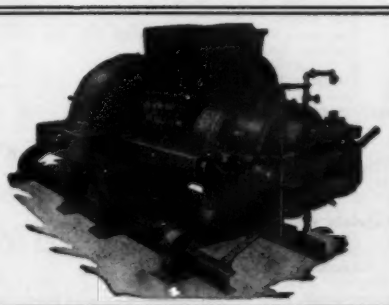

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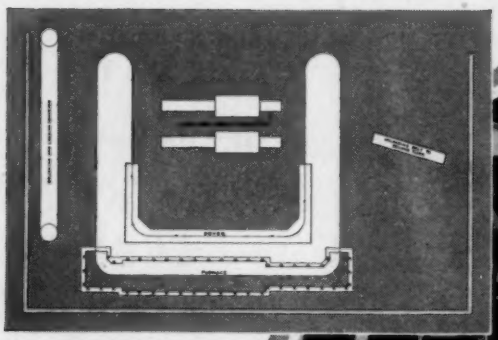

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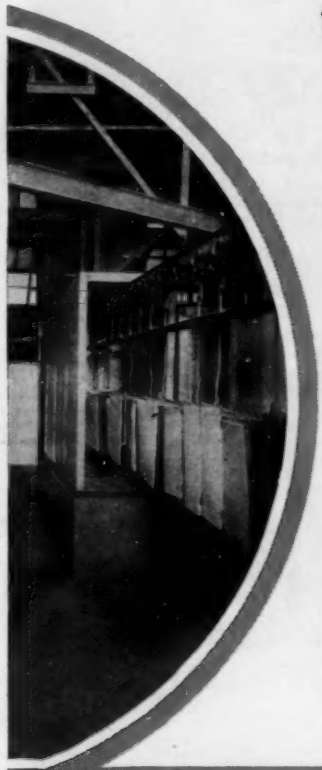

WITHIN a year the economies and improvements effected by this furnace paid practically the entire cost of the installation at Cribben and Sexton Company, famed manufacturers of ranges.

Formerly they were using three batch type furnaces and one batch type dryer.

Fuel costs were high and labor charges ran three times the present figures.

The Carborundum engineers designed and installed a continuous enameling furnace and dryer to replace the batch type equipment.

The system of handling ware with the new installation reduced labor costs from $900.00 to $310.00 per week.

Spoilage was materially decreased; fuel costs were appreciably lowered and the whole burning and drying process was improved.

The Carborundum installation consists of a continuous enameling furnace and an attached heat interchanger from which hot, clean air is obtained for drying.

The furnace is indirect gas-fired; heat being delivered to the work through a "Carbofrax" muffle.

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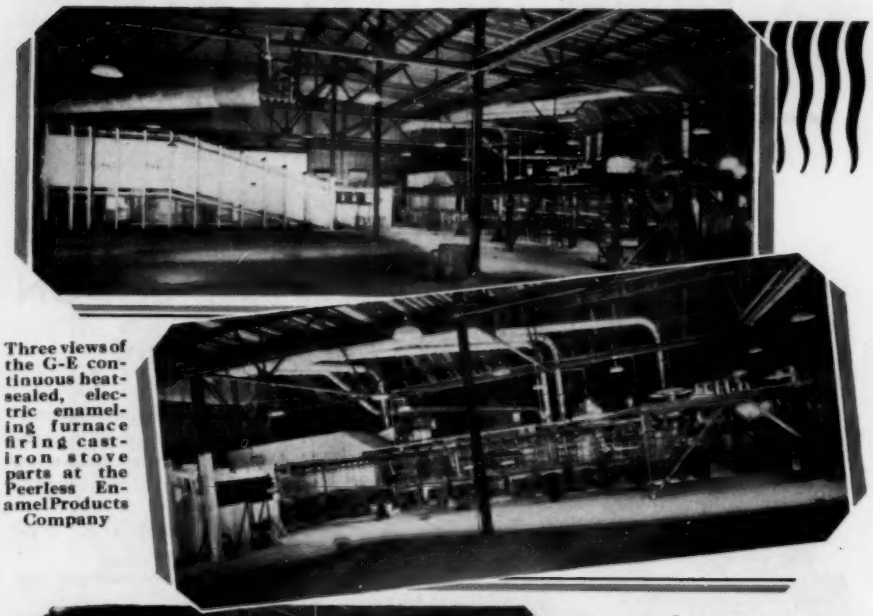

Three views of the G-E continuous heat-sealed, electric enameling furnace firing cast-iron stove parts at the Peerless Enamel Products Company

It isn't the cost of repairs that worries an enameler when his furnace breaks down—its the very serious loss of production. The General Electric continuous, heat-sealing enameling furnace assures continuity of operation because it is one of the most dependable pieces of equipment built. If this were not so, General Electric would not be using 14 of these furnaces in producing its refrigerators—a field of manufacture where continuity of operation is all-important.

GENERAL

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1. Approximately 18 per cent reduction in the cost of enameling
2. Approximately 50 per cent improvement in the appearance of the work (resulting in increased sales)
3. Virtual elimination of costly, annoying rejects
4. A greatly appreciated improvement in working conditions

Future savings will show up, also, in the big reduction of maintenance and the absence of costly shutdowns, made possible by the combination of Electric Heat efficiently utilized in a furnace of sound design and construction.

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GENERAL ELECTRIC

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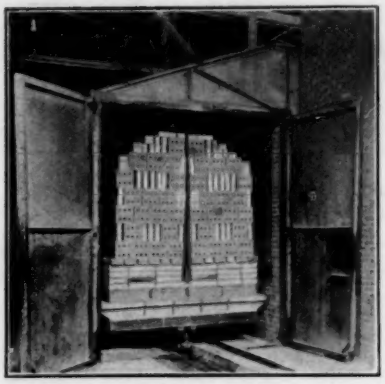

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Production costs are low, because:

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2—Power for air circulation costs only 6¢ per 1000 bricks.

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4—Output is high—20% greater than guaranteed.

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